ZOOGOER

JULY • AUGUST 1990

Friends of the National Zoo

is a nonprofit organization of individuals, families, and organizations who are interested in helping to maintain the status of the National Zoological Park as one of the world's great zoos, to foster its use for education, research, and recreation, to increase and improve its facilities and collections, and to advance the welfare of its animals.

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The National Zoological Park is located in the 3000 block of Connecticut Avenue, N.W., Washington, D.C. 20008, (202) 673-4717. Weather permitting, the Zoo is open every day except Christmas. Hours: From September 16 to April 30, grounds are open from 8:00 a.m. to 6:00 p.m.; buildings, 9:00 a.m. to 4:30 p.m. From May 1 to September 15, grounds are open from 8:00 a.m. to 8:00 p.m.; buildings, 9:00 a.m. to 6:00 p.m.
Director: Michael H. Robinson.

Membership in FONZ entitles you and your family to many benefits:publications, discount privileges, and invitations to special programs and activities to make your zoogoing more enjoyable and educational. To join, write FONZ Membership, National Zoological Park, Washington, D.C. 20008, or call (202) 673-4960.

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JESSIE COHEN/NZP GRAPHICS

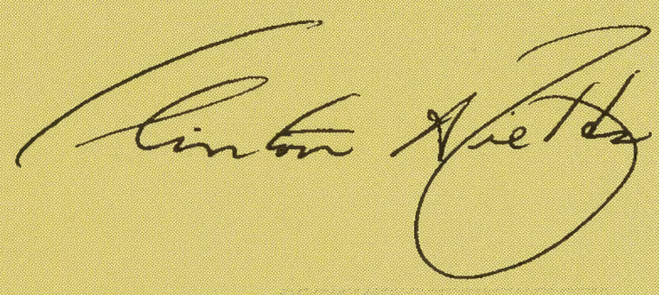
Member Benefits

On two beautiful evenings in June, more than 10,000 FONZ members turned out for our annual ZooNights. Kids had their faces painted like leopards and enjoyed free popcorn and sodas. Families explored behind the scenes at the Australia Pavilion and the Small Mammal and Reptile houses. From newborn babies to grandparents, nearly everyone had a T-shirt screened, more than a few of whom proudly displayed a frayed, faded T-shirt with ZooNight designs going back six to ten years. And it almost goes without saying that all enjoyed wandering through the Zoo, visiting old favorites like the giant pandas and the giraffes, and getting acquainted with new residents like the baby servals and Siberian ferrets.

ZooNights are our way of saying thank you to all of the FONZ members who contribute so much to the Zoo all year around. It is often unrecognized that the contributions of FONZ members go far beyond their basic annual dues. Members form our cadre of incredible volunteers who contribute more than 60,000 hours of service to the Zoo each year. Members are loyal and significant patrons of FONZ's food and gift concessions, the profits from which support Zoo research, conservation, and education programs. In the last year, members donated more than $90,000 for new Zoo exhibit initiatives, including Cheetah Springs and the Children's Trail. Member donations purchased benches throughout the Zoo in a program so successful we had to discontinue it—the Zoo is full of benches! More than half of the guests at our ZooFari fundraiser for the Zoo's Animal Acquisition Fund were members, who also donated nearly $40,000 through the ZooFari Sweepstakes, helping to make the 1990 ZooFari our most successful ever. And members contribute in countless other, immeasurable ways. They offer ideas and enthusiasm, and they spread the word, in Washington and around the world, about the Zoo and its conservation, research, and education missions.

The National Zoo boasts many treasures: a diverse collection of marvelous animals, a beautiful landscape, historic buildings, a dedicated, highly skilled staff. And it has FONZ members, who individually and collectively are among the Zoo's greatest assets.

On behalf of FONZ and the Zoo, I thank you, our members, for your support.



Clinton A. Fields

ZOOGOER

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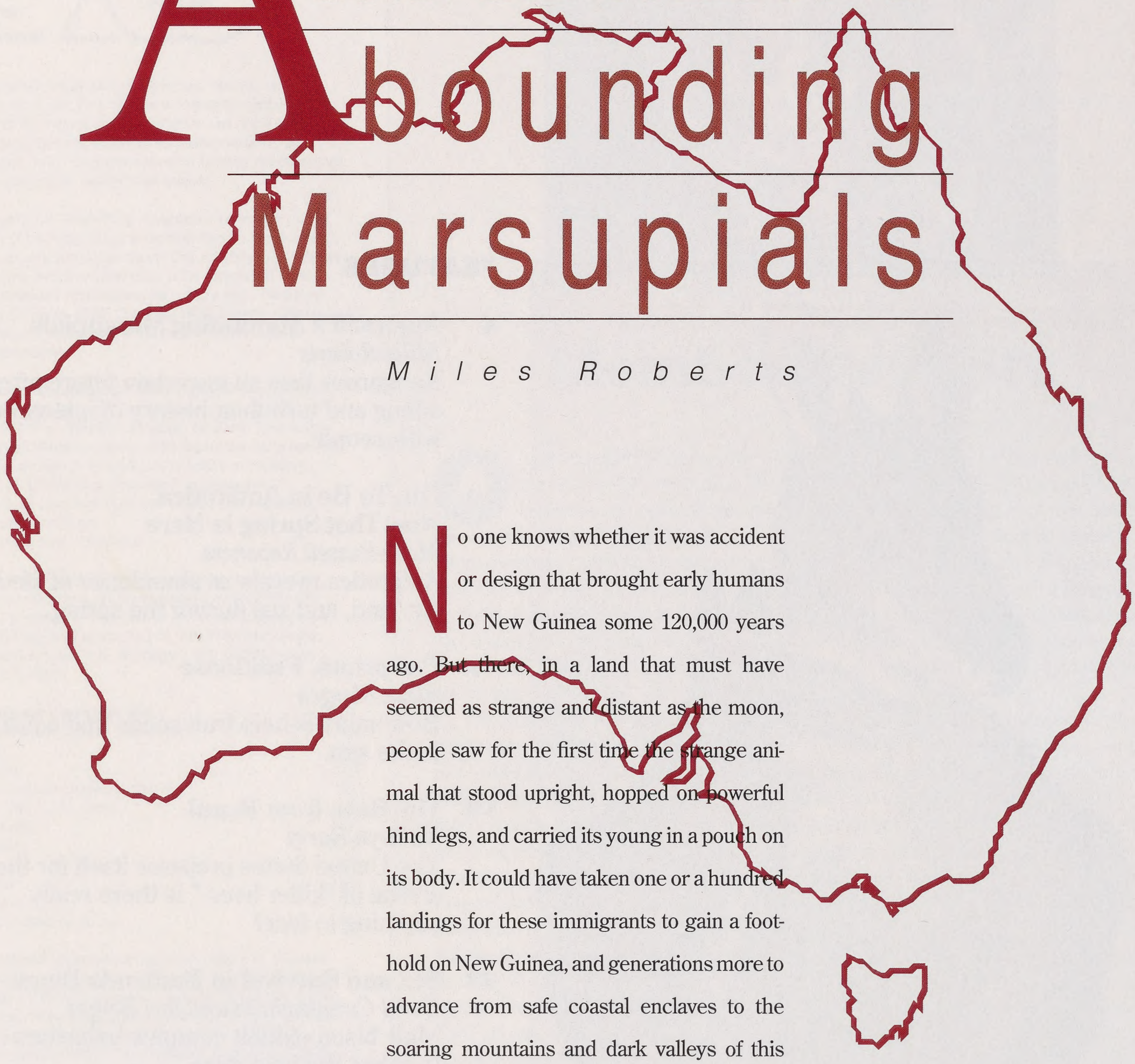
Hand-colored engraving of black-faced wallabies by 18th-century naturalist John Gould. Most famous for his bird paintings, Gould wrote several monographs on the mammals of Australia. (Photo by Miles Roberts/Courtesy of Smithsonian Institution Libraries.)

FEATURES

DEPARTMENTS

Australia's Abounding Marsupials



Miles Roberts

No one knows whether it was accident or design that brought early humans to New Guinea some 120,000 years ago. But there, in a land that must have seemed as strange and distant as the moon, people saw for the first time the strange animal that stood upright, hopped on powerful hind legs, and carried its young in a pouch on its body. It could have taken one or a hundred landings for these immigrants to gain a foothold on New Guinea, and generations more to advance from safe coastal enclaves to the soaring mountains and dark valleys of this second largest of all islands. Traveling inland, humans would have encountered kangaroos everywhere: in murky swamps, amid luxurious rainforests, on verdant plains, and on rocky escarpments, for New Guinea is home to 15 kinds of wallabies, pademelons, and tree-kangaroos, almost one-quarter of all living macropod species. These first human inhabitants were hunter-gatherers; for millennia to come they would eat kangaroos, wear their hides, use their sinews to bind weapons

Black-faced wallaby *(Macropus fuliginosus)* at the edge of a sugar cane field in Queensland. *(Photo by Miles Roberts.)*

and tools, and use their bones as body ornaments.

Humans may have arrived on New Guinea abruptly, but kangaroos appeared there gradually some 15 million years ago. At that time, New Guinea was connected, above sea level, with the northern edge of the Australian continent, and the entire landmass was drifting northward on the Indo-Australian Plate. At about the same time as what is now the northern half of New Guinea was heaved from the sea by tectonic forces from the collision of two of the earth's colliding crustal plates, a small, arboreal marsupial began its descent from the trees in the rainforest and an ascent from obscurity. Small, omnivorous, minimally modified for hopping and maximally adapted for avoiding the huge lizards, snakes, and crocodiles that dominated the landscape, this was the proto-kangaroo, a minor player in the great biotic drama of the time.

For the next several million years, warm and moist conditions prevailed over the Australia-New Guinea landmass. One kangaroo lineage evolved as herbivores and another as omnivores, but both remained small in stature and trivial in consequence. Around eight million years ago, a great cooling and drying period commenced over the earth, and, in Australia's interior, rainforest gave way to open woodland and savanna. Some kangaroos, apparently able to adapt to drier conditions, became larger and even more specialized for eating the grasses that flourished in the new environment. Elsewhere, giant browsing kangaroos, some almost 10 feet high and weighing almost 450 pounds, and carnivorous ones that ate other kangaroos, evolved to share the scene with saber-toothed marsupial carnivores, rhinoceros-sized marsupial phalangers related to modern bushtail possums, giant emus, and other outlandish giant vertebrates. It was a turbulent period in the faunal evolution of Australia, and it was to be the heyday of kangaroos.

The great glaciations, starting two million years ago, brought even drier conditions and heralded the beginning of the end for the great megafauna. As the prehistoric giants declined, many new species of arid-zone kangaroos evolved, such as the hare-wallabies, the nail-tailed wallabies, and the red kangaroos, and the Australian kangaroo fauna began to take on the character it would have when first encountered by humans 60,000 years ago.

Rock wallabies by John Gould. *(Photo by Miles Roberts/Courtesy of Smithsonian Institution Libraries.)*

Humans almost certainly reached Australia by the land bridge with New Guinea, located approximately where Cape York Peninsula is now. Then they followed the "riverine corridor," a wide course of watersheds roughly parallel to the spine of the Great Dividing Range of eastern Australia, where streams and rivers watered vast grasslands well stocked with fowl, fish, and many other foods.

But kangaroos were the most important game for the aborigines. One kangaroo was a substantial meal for a small band, but it required great skill, energy, and patience to obtain. A quick kill was the rare exception, and most kangaroo hunts involved chases of many miles in the grueling heat of the day, elaborate drives toward concealed spearmen, or long, patient ambushes at waterholes. But the use of fire for driving kangaroos from concealment, or toward hunters, was perhaps the most effective aboriginal hunting technique. Not only did purposefully set fires make it easier for hunters to catch kangaroos, but fired areas rebounded with a flush of green succulent vegetation particularly attractive to these grazing animals. Recent research has shown that fired areas tended to remain as grasslands, the preferred habitat of the larger kangaroos, or were invaded by fire-tolerant trees, such as eucalyptus. Some scientists now believe that the aborigines' use of fire for hunting, sometimes called "firestick farming," may have directly fostered kangaroo numbers and significantly altered Australia's biotic landscape over the millennia.

Aborigines were probably the kangaroos' most significant predator. Frederick McCarthy and Norman Tyndale, Australian ethnoecologists working in different parts of Australia, found that a band of ten aborigines would consume about six kangaroos a week. Using this figure, and estimates of peak aboriginal numbers in Australia, they calculated that aborigines accounted for roughly 160,000 to 175,000 kangaroos killed per year. This may seem like a lot, but it is a fraction of today's kangaroo industry take of 2.5 million animals annually.

Giant kangaroos finally went extinct about 10,000 years ago, along with a number of other large vertebrates. There can be no question that aborigines hunted giant kangaroos, for their remains have been found in prehistoric middens dated as far back as 26,000 years before the present. But there is no conclusive evidence that aborigines caused their extinction. Available evidence suggests that giant kangaroos were already under severe ecological stress from repeated and prolonged droughts, and human depredations merely hastened the inevitable. The rapid end of the giant kangaroos, coming at about the same time as the Ice Age extinctions of large animals in the northern hemisphere, even suggests that a fundamental global process was at work.

As an important source of such essentials of life as food, hides, ornaments, and tools, it is not surprising that kangaroos figured prominently in aboriginal lore and ritual. According to Aranda legend, for example, the Dreamtime began with a flat, featureless world upon which there were no people, animals, or plants. Malu the kangaroo, and Kunjula the euro (a type of kangaroo), two of the most important Dreamtime beings in the aboriginal pantheon, created the waterholes, creeks, and mountain ranges, then the es-

sential laws and rituals.

Although aborigines credited kangaroos for creating many of the good things in nature, one Wiradjuri story explaining the origin of kangaroos cites a Dreamtime being—specifically, an angry man—as the "creator" of the kangaroo. As the Wiradjuri legend goes, two men in the Dreamtime were quarreling when one of the men hurled a spear into the other's buttocks. The reluctant recipient of this wooden appendage became a kangaroo in our world. The colored ocher clays with which many aborigines decorate themselves and their weapons during ritual dances, or corroborrees, are said to be the blood (red ocher), liver (yellow), and bile (green) of a kangaroo speared in the Dreamtime. Kangaroos were also painted on rocks at waterholes, and in cave galleries to evoke their power and wisdom and to ensure their abundance.

Aboriginal stories about kangaroos were more than whimsical anecdotes, they were also verbal roadmaps and field guides. A story of how the Dreamtime kangaroo created this waterhole, that pile of boulders, a dry canyon, or a series of dunes was, among other things, a mnemonic to help the individual negotiate his or her way through a relatively featureless desert landscape. Furthermore, many aboriginal myths about kangaroos may have been founded on some vital aspect of kangaroo behavior or ecology, as Alan Newsome, an Australian kangaroo biologist, recently demonstrated. Newsome found that one particular Aranda songline described mythic red kangaroos traveling along geographic features that didn't seem actually to exist in Aranda territory. But upon further investigation, Newsome discovered that the songline landmarks corresponded almost exactly with former habitat features, undoubtedly of ecological importance to kangaroos, long since obliterated by European farming and grazing.

Between 10,000 years ago and 200 years ago, humans and kangaroos lived more or less at equilibrium. Only one species of kangaroo is believed to have gone extinct over this entire time, and it was a species of little economic importance to the aborigines. But this ecological harmony began to change about 200 years ago with the arrival of Europeans, their firearms, and their domestic animals.

Europeans, most likely Portuguese explorers, probably first saw Australia in the early-to-mid 1500s, but it is hard to know whether they saw kangaroos. The earliest evidence of a European kangaroo sighting occurs in *Speculum Orbis Terrae*, a 1597 book by Dutchmen Gerard and Cornelius de Jode. On the title page appears an odd, long-necked creature with two small babies peering out of a pouch; possibly it was meant to be a kangaroo. The first written description of a kangaroo appears in 1629 when Dutchman Francisco Pelseart, while rescuing marooned seamen from the wreck of the ship *Batavia* on the Wallabi Islands off the coast of Western Australia, described what is believed to be the Tammar wallaby. He writes of the animals as "a species of cats, which are very strange creatures." Their strangeness didn't stop the marooned survivors from eating them until rescuers arrived, however. Dutchmen Samuel Volkerstein in 1658, Willem de Vlamingh in 1698, and Nicolaes Witsen in 1705 describe a small kangaroo from Rottnest Island, also off the coast of Western Australia, as "a cat," "a rat as big as a cat," and "rats as large as cats," respectively. Following a slightly different tack, English buccaneer-cum-explorer William Dampier described the banded hare-wallaby of Western Australia as: "... a sort of raccoons different from those of the West Indies." And, like his predecessors, he too found these creatures strange but tasty.

Errant descriptions by seamen untrained in biology continued until James Cook's first voyage to Australia in 1770. Sir Joseph Banks, a renowned English botanist, accompanied Cook on this voyage, and for the first time someone with formal scientific training examined Australia's biota. On June 10, 1770, while charting the east coast of Australia near what is now Cooktown, Cook's ship, the *Endeavour*, struck a reef. Only miraculous luck and extraordinary effort by the crew saved the day, and Cook was able to beach the craft at the mouth of a river for repairs. For the next seven weeks, Banks, Cook, and the crew collected plants and animals and made their first observations of kangaroos being cooked and eaten by aborigines. Naturally, they shot and ate kangaroos themselves. Sydney Parkinson, ship's artist and scribe, records their first impressions of a kangaroo as: "... an animal of a kind nearly approaching the mus genus, about the size of a gray-hound, that had a head like a fawn's; lips and ears, which it throws back, like a hare's." A real zoological medley.

Like the laymen before him, Banks was unable to place the creature taxonomically. The first ones shot were males and lacked pouches; therefore, Banks didn't make the mental connection between the kangaroo and the North American opossum and various other marsupials he had seen and collected in South America. Banks was apparently the first person to use the native word "kanguru" for the animal. Banks thought "kanguru" referred to the animal itself, but no aboriginal dialect uses this word for a kangaroo. As the possibly apocryphal story goes, the local aborigines, unable to understand Banks' inquiries into the animals' name, were merely replying "We don't understand" or possibly even a colorful epithet about Banks' ancestry.

Cook sent three kangaroo specimens back to England pickled in brine. Included in his journals of the voyage, published in 1773, is a plate by J. Stubbs of a kangaroo, the first portrait of the animal. Based on Cook's specimens and a sketch by ship's artist Sydney Parkinson, it remained for years the definitive, and most imitated, image of the kangaroo. In 1776, P.L.S. Muller made the first scientific description of the kangaroo, based on Cook's material, naming it *Mus cangaru*. It was an interesting choice of name. *Mus* is the generic name of the common house mouse, alluding both to the kangaroo's conspicuous hopping gait and to the obvious confusion over its taxonomic relationship.

Little news of kangaroos followed until the First Fleet landed in Australia in 1788 to establish the infamous penal colony at Botany Bay. In July of that year, Governor Arthur Phillip wrote to Sir Joseph Banks of a kangaroo that "grew to a great size. One has been killed that weigh'd very near Two hundred weight." Not all human encounters with kangaroos proved fatal to the animal, however. One of Phillip's men tamed a young kangaroo and, presaging the kangaroos' future prominence in zoos, a John White, Esq., sent the first live kangaroo to England in 1791, where it was exhibited in the Strand for the princely

Eastern gray kangaroos *(Macropus giganteus)* are gregarious, and feed on grasses during daylight hours. *(Photo by Miles Roberts.)*

The Ins and Outs of Kangaroo Life

Most kangaroos are herbivores. The larger, more familiar ones, like red and gray kangaroos and many of the larger wallabies, graze mostly on grasses in the open forests and savannas. Medium-sized, forest-dwelling species, like swamp wallabies, tree kangaroos, and wallaroos, browse mostly on leaves. The small forest inhabitants, the rat-kangaroos, bettongs, and musky rat-kangaroos, are inclined toward omnivory; and some eat fungus, tree-gum residues, insects, and even carrion. As a group, kangaroos are remarkably like ungulates in their dietary habits and have even evolved similar means for digesting foods high in plant fiber and low in protein. Both groups have multi-chambered stomachs that house bacteria to break down plant cell walls and liberate the digestible cell contents. In some respects, however, kangaroos are more diverse than the ungulates, for no ungulates live in trees or in extensive burrow systems like some kangaroos do.

Kangaroo distribution and dietary habits have an effect on their reproduction and social behavior. Those living in habitats with predictable periods of resource abundance, such as in the southeast of Australia where spring and autumn rainy seasons are the rule, generally have one litter a year with high offspring survivorship. The timing of reproduction is such that the young are weaned when resources are at a peak. In arid habitats, such as central Australia where rainfall is unpredictable, kangaroos breed any time that plant growth responds to unpredictable rains. By being opportunistic they may have more than one litter per year, albeit with higher rates of offspring mortality.

The unpredictable nature of resources has led to the evolution of a reproductive strategy in which females of some species may care for three litters simultaneously. This transpires when the mother comes into estrus and breeds immediately after the birth of one infant. The embryo so produced remains in the mother's uterus in a state of suspended development, called "embryonic diapause," until the pouch young is weaned. The mother may have yet another offspring, one that has just left the pouch, in attendance at the same time. Thus, the mother may have a weaned older offspring at heel, another in the pouch, and yet a third in suspended development in the uterus all at once.

"Kangaroo social life is still something of a mystery, for few species have been studied in much detail."

Kangaroo social life is still something of a mystery, for few species have been studied in much detail. Small species, such as potoroos, bettongs, and musky rat-kangaroos tend to be solitary, with male home ranges encompassing those of several females. Individuals sleep alone in nests, usually in clumps of grass or other vegetation, and males awaken a few minutes before the females and visit them to test their reproductive condition. Brief sexual consortships and the mother-young association are the only social life apparent for many of these species.

At the other end of the social continuum lie the larger kangaroos such as the reds and the grays. They form loose, mixed-sex groups, called mobs, and males form a dominance hierarchy based largely on age and size, with the most dominant male having exclusive mating access to estrous females. The big male, or boomer, spends much of his time wandering in and out of the mob, testing the reproductive condition of females, mating with them, and muscling out potential challengers. While it may take 10 years to achieve alpha status, his sweet tenure is short—a year at most. Eventually he is bested by a younger, more vigorous male, leaves the group, and dies soon after.

—Miles Roberts

admission price of one shilling.

Kangaroos featured prominently in the early days of the fledgling colony. The gentry enjoyed hunting them on horseback with dogs, the object being a sporting chase and a kangaroo tail for the soup pot. Foxhounds and greyhounds were badly outmatched by the formidable size and superior maneuverability of most kangaroos, so a new breed, the Kangaroo Hound—a cross between the greyhound and the deerhound—was developed just for the hunt.

To the convicts and freemen at the other end of the social scale, who struggled to establish European agricultural and livestock practices in a hard and resistant land, kangaroos were an important source of bushmeat and hides. Later, kangaroo meat enabled early explorers to penetrate the vast interior beyond the tether of bulky provisions. Abundant the animals were, too. In the journal of his 1813 expedition, John Oxley, Surveyor-General to Governor Lachlan Maquarie and among the first explorers to travel inland extensively, makes frequent note of large aggregations of kangaroos close to Sydney. But this situation soon changed. Less than 20 years later, Major Thomas Mitchell, on his way inland to search for rivers and arable land, retraced Oxley's path and, noting the scarcity of kangaroos, remarked that "the kangaroo was either destroyed or banished." Farmers and graziers, however, perceived that there were still more than enough of the bounders.

The slow but inevitable spread of agriculture and livestock bode ill for kangaroos. Kangaroos seemed irresistibly attracted to farms and wells, where they ate crops and drank precious water. Convinced that pastoral activities only generated more kangaroos, farmers and graziers shot and poisoned them at will. Amazingly, despite farmers' efforts at eradication, kangaroos flourished. By the mid-19th century, the perceived pests provoked some states to enact legislation *requiring* landholders to exterminate kangaroos; as an incentive, the government added fines for noncompliance and bounties for scalps. Not surprisingly kangaroo shooting quickly became a professional occupation. A few enterprising shooters found a ready market in North America and Europe for the meat and hides that would otherwise have rotted in the fields, and a new Australian industry was born.

In the early days, public opposition to the killing of kangaroos was negligible. But by the late 1800s, the deadly efficiency of kangaroo shooters made it difficult to find a kangaroo within a day's ride of a city. As Vincent Serventy, one of Australia's foremost natural historians, put it: "The result of this hunting was that from the average person's point of view the kangaroo was extinct." Concern about the fate of kangaroos, and indeed about the future of all Australia's wildlife resources, has grown steadily since. But most public opinion generated over kangaroos focuses on the half-dozen species of commercial value; public awareness of the remaining 50 or so species is virtually nil, even in Australia. Few know that kangaroos constitute an astonishingly diverse mammalian radiation, occupying virtually every major Australian habitat type (*See Box.*)

Most kangaroo research has focused on estimating the number of animals in the wild, their impact on agriculture, and the effects of

hunting and climate on wild populations. Some results have been startling. One study found that the numbers of kangaroos on the western plains of New South Wales doubled between 1975 and 1982, then crashed by 43 percent during the severe drought of 1982. Another study confirmed that the population growth of kangaroos is directly related to rainfall patterns; still others have demonstrated that kangaroos and sheep in the same field eat different plants and plant parts and, contrary to farmers' long-held beliefs, may not actually be in direct competition with one another. These kinds of studies are crucial for predicting and shaping the future of kangaroos.

And what of their future? Land development, agricultural expansion, and habitat degradation occur in Australia just as they do elsewhere in the world. With such "progress" comes a diminution of suitable habitats for kangaroos and increased competition with humans for available resources. The result is declining numbers of the rarer and more sensitive species and increased demands for removal of those whose populations remain stable, or even increase, on the human-altered landscape. In short, the future of kangaroos will depend on the actions of human governmental bodies. But the priorities of such bodies will be dictated by public opinion.

The future of kangaroos is not only an Australian concern. As the proclaimed symbol of Australia, the kangaroo is loved and known the world over and has become a cause celebre among international conservation organizations, nowhere more so than in the United States. Most public opinion generated over kangaroos has focused on the six or so larger species that are culled and on the justification for the culls. Each of the six Australian states has a kangaroo-harvesting policy in which the target species and numbers to be taken each year are based on aerial and ground surveys of kangaroo populations and population growth projections. Not surprisingly, there has been worldwide controversy about whether current cull levels, now running at about 2.5 million animals per year, are appropriate. In the mid-1980s in the U.S., there were numerous articles, op-ed opinions, and letters to the editor about the role and responsibilities of the United States on this issue. Many people in Australia, some biologists among them, support the kangaroo cull to protect Australia's agricultural productivity, a major component of the country's economic base. As they have done for a century and a half, farmers argue for an unlimited cull, and conservationists tend to support complete preservation. The debate continues, and biologists monitor kangaroo populations more closely than almost any other large mammal anywhere on earth.

Some creative solutions to the kangaroo "problem" have been proposed. The most interesting recognizes that for millions of years kangaroos have been adapted to habitats where sheep and cattle now barely eke out an existence. It goes on to argue that kangaroos should be allowed to replace sheep and cattle as the principal rangeland stock in certain marginal habitats. Other ecological benefits would result because kangaroos are more efficient consumers of native vegetation than introduced sheep or cattle, and do not overgraze and lacerate the landscape like the sharp-hoofed ungulates. The proposal also suggests that, by raising the price of kangaroo meat from the current pet-food rate of about seven cents per pound to a more economically viable price, farmers could be induced to switch from sheep to kangaroo "farming." All this assumes that there's a market for kangaroo meat, of course, and, surprisingly, there might be. Recent test marketing surveys suggest that kangaroo meat would sell as a gourmet food, and palatability tests compare its flavor and tenderness favorably with beef.

Other suggested solutions to the "problem" include shooting kangaroos with contraceptive pellets, erecting huge kangaroo exclosure fences, and raising kangaroos under feedlot conditions, like beef cattle. Whether any of these proposals receive wide acceptance remains to be seen, but one thing is certain: The debate over kangaroos is likely to continue for a long time to come.✤

Miles Roberts is Deputy Head of the Zoo's Department of Zoological Research.

Eastern gray kangaroos under eucalyptus trees in Marramurang National Park in New South Wales. Kangaroos are protected from hunting in Australia's national parks. *(Photo by Miles Roberts.)*

OH, TO BE IN ANTARCTICA NOW THAT SPRING IS THERE

Mary-Russell Roberson

Imagine you are standing in the middle of Antarctica, equipped with binoculars and field guides. What do you see? Chances are, you do not see a single animal. Less than five percent of the landmass supports life. Not surprising, when you consider that ice up to two-and-a-half-miles thick shrouds all but two percent of Antarctica. You probably don't see much in the way of plants either—vegetation covers only one percent of the landmass. Most of the continent's wildlife consists of microbes, protozoans, insects, fungi, lichens, algae, and mosses. Antarctica is home to no indigenous peoples, no amphibians or reptiles. No fish or birds live in or around the continent's lakes.

Slick Weddell seal pup emerges from a swim.

Now, imagine you are standing on one of Antarctica's beaches. It is the austral spring—September through December. What do you see? Millions and millions of animals feeding, courting, breeding, and raising their young.

Along the beaches and cliffs, you see colonies of tens and even hundreds of thousands of penguins. Parents, returning from the sea, are calling noisily to their young, who are in turn calling to their parents. Somehow each parent picks out its own offspring from among the thousands of young penguins. Beak to beak, the parent feeds its young regurgitated seafood. Skuas, gull-like predatory birds, hover above the penguin colonies, ready to nab an unattended egg or chick.

Opposite page
Antarctica's beaches teem with wildlife during the austral spring.

If you happen to be standing on one of the beaches of Antarctica's islands, say the South Shetland Islands off the Antarctic Peninsula, you will likely see colonies of elephant seals near the penguin colonies. Male elephant seals, weighing about two tons, trumpet and lumber about on the open beaches, defending their females from other males. On more remote beaches, you might see fur seals engaging in similar behavior.

Walking out on the "fast ice," the ice that forms on the sea and connects the islands to the continent, you see groups of Weddell seals clustered around holes—doorways to the sea—that they've enlarged with their teeth. Farther out, on the pack ice in the sea, you can make out small groups of leopard, Ross, and crabeater seals.

From cliffs overlooking the sea or out in a boat, you may spot many of the more than a dozen species of whales surfacing between feeding bouts. Seals and penguins of all kinds speed through the water, hunting and feeding. Seabirds, such as prions, petrels, skuas, and fulmars, wheel in the air above the ocean, some diving for fish, others skimming the top of the water for tiny animals and plants.

In addition to these large, easily seen species of animals, Antarctica's coasts and seas are home to many species of fish and invertebrates, such as cephalopods (squid and octopus), and crustaceans (shrimp and crab), tiny aquatic plants (phytoplankton), and tiny aquatic animals (zooplankton).

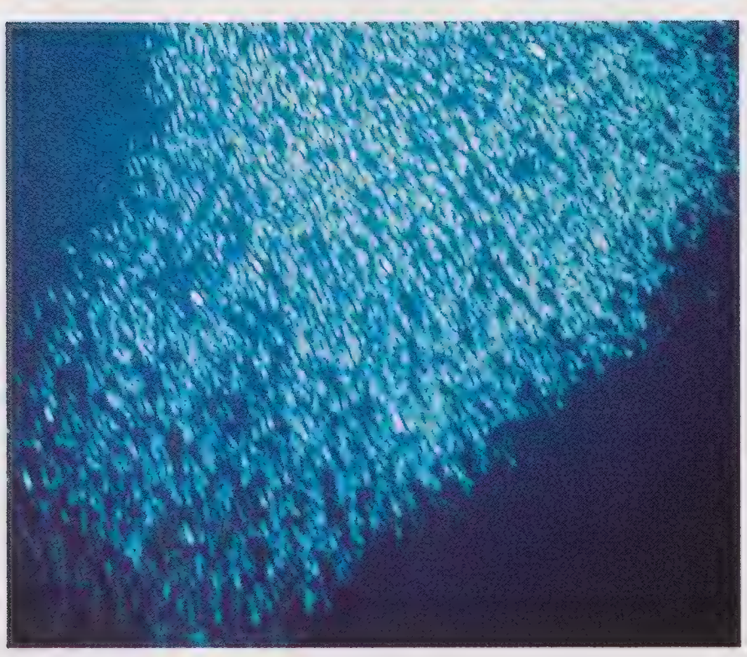
In the winter, Antarctica's coastline isn't as active. Most of the species of birds, seals, and whales spend the coldest months in warmer areas farther north; they come to Antarctica in the spring and summer to feed in the rich seas while breeding and raising their young.

Compared to temperate or tropical ecosystems, Antarctica supports relatively few animal species, even in the spring and summer. However, those few species contain incredible numbers of individuals. For example, only six species of seals live in Antarctica, but more individual pinnipeds (the group of marine mammals that includes seals, sea lions, and walruses) inhabit the seas of Antarctica than live in all the rest of the world put together. Of Antarctica's six species, crabeater seals are the most abundant, numbering somewhere between 15 and 75 million. In fact, Antarctic crabeaters alone probably make up more than half the world's pinnipeds.

Only 18 bird species, including penguins, fulmars, petrels, prions, and skuas, breed on Antarctica and adjacent islands. But again, those few species contain millions of birds. One penguin breeding colony alone can contain hundreds of thousands.

The abundance of one tiny resident of Antarctic waters is primarily responsible for most of the springtime crowds. Krill, shrimplike creatures about an inch long, swarm in the spring and summer, providing food for seals, birds, fish, cephalopods, and whales—including the largest animals on earth, blue whales. One swarm alone may contain up to 10 million tons of krill.

Krill populations explode during the austral summer. Huge swarms, containing up to ten million tons of krill, support all manner of marine life from fish to birds, to whales and seals.



Seven species of baleen whales—the minke, sei, right, fin, humpback, pygmy blue, and the blue—migrate to Antarctica each spring to gorge on the massive swarms of krill. Also called toothless whales, baleen whales strain krill from the sea by gulping in water, then expelling it through sieve-like plates, called baleen, that hang from their upper jaws. While in Antarctic waters, the whales increase their weight by 30 to 100 percent. They live off this weight the rest of the year, when they feed only sporadically. After feasting on krill, the whales migrate to warmer waters north, give birth, and breed. They and their offspring will return to Antarctica the next spring to feed. The staggered arrival times of the different species ease the competition for krill.

In contrast to the baleen whales, toothed whales are not seasonal feeders. Nor do they eat krill, though they feast on species that do. Sperm whales, one of eight species of toothed whales that frequent Antarctic waters, dive as deep as 3,900 feet, using echolocation to find squids and fish. Sperm whales easily swallow most fish and squids whole, but giant squids may give them a fight, leaving the whales with sucker scars. Bottlenose and beaked whales are also thought to dive and use echolocation to find food. Killer whales, which range worldwide, hunt in groups and use their teeth to grasp and tear fish, cephalopods, birds, seals, and other whales.

Pair of skuas circling near McMurdo. Skuas will often rob unattended penguin nests, feeding on the chicks or eggs.

All of Antarctica's six pinniped species rely on krill as well, either directly or indirectly. The variation between their diets ensures that millions of individual seals and sea lions get enough food.

Like the baleen whales, crabeater seals and leopard seals strain krill out of the seawater. Instead of baleen plates, however, scientists think the seals use their serrated, well-spaced teeth to trap the small crustaceans in their mouths. Despite their name, crabeaters eat krill almost exclusively. Leopard seals, which also eat invertebrates and fish, are the only Antarctic pinniped species to prey on penguins and crabeater pups.

Ross seals and southern elephant seals eat primarily squids and octopuses, which live deep in the ocean. Scientists think that the enormous eyes of Ross seals help them see their prey in the ocean's dark depths. Ross seals probably also eat fish, krill, and other invertebrates. Deep-diving southern elephant seals have a special pigment in their eyes that may help them detect the bioluminescence of some deep-sea squids. Although no one has studied the depths to which southern elephant seals dive, northern elephant seals in California have been known to stay underwater as long as an hour and to dive down as far as 4,125 feet!

The seals come to Antarctica not only to eat, but to breed and give birth as well. The pinnipeds vary as widely with respect to breeding and pupping behavior as with respect to diet. It is the variation between each species' niche that allows Antarctica to support as many different species as it does.

Antarctic seals give birth and mate from

late September to early November. Female crabeaters give birth to pups on pack ice. Typically, a male, female, and pup will stay together on an ice floe while the pup nurses. After about a month, during which time the fasting female loses roughly half her weight, the pup is weaned and abruptly abandoned by its mother. The male and female leave together and mate either on the ice or out at sea. Ross seals and leopard seals also breed on pack ice, about a month later than the crabeaters.

Elephant seals and fur seals breed on land, displaying markedly different behaviors than the three pack-ice breeders—the crabeater, Ross, and leopard seals. Male elephant seals begin gathering on open beaches in September. Shortly thereafter, females join them and give birth. Males, sometimes seven times as large as females, defend harems containing as many females as they can manage. The largest and strongest males usually control the largest harems. They establish dominance by warding off other males with trumpeting clap-threats, hollow rumbling sounds produced by blowing air through their long noses, and by displaying their size and occasionally fighting. Before the females finish nursing and return to the ocean to feed, the dominant bulls mate with as many females as they can. During pupping season, females fast while nursing; males may also fast for long periods during the breeding season.

Fur seals, which also give birth on land, gather on rockier and more remote beaches than the elephant seals. Male fur seals haul out before the females and begin jockeying for position on the beach. Females arrive and give birth in November; 80 percent of the pups are born in a 17-day period. Eight days after the females give birth, males mate with females and then head back out to sea. After the males leave, females spend about three months alternating feeding trips of about four days with attendance and nursing bouts of about two days.

The Weddell seal breeds and gives birth on fast ice—the only species of Antarctic seal to do so. Because the surface of the water is completely covered with ice, the seals establish rookeries around cracks in the ice, usually enlarging the holes with their large front teeth. Pupping is concentrated around these breathing holes. While the females nurse, males defend aquatic territories underneath the pupping colonies, keeping other males from using their breathing holes. Shortly before the pups are weaned, the adults mate underwater.

While seals are busy feeding, breeding, and giving birth, Antarctic birds are doing the same. Most species, apart from the skuas, gulls, and terns, nest in large colonies. Many of these colonial birds, including penguins, albatrosses, and petrels, lay only one egg. When the chicks are born, they are covered in a heavy down to protect them from the cold. Still, parents must brood them for several days or weeks before leaving them alone. Young petrels and penguins grow a layer of fat that will protect them and sustain them when their parents leave them for molting and migration. In fact, some young petrels put on so much fat that they outweigh their parents. After a week or so of living off fat reserves, the young begin to feed themselves.

The birds, like other Antarctic animals, glean their food from the sea. The five species of penguins that live on the Antarctic continent and peninsula eat krill, fish, and squids. The largest penguin, the emperor (which reaches almost four feet in height), can dive as deep as 820 feet and stay underwater as long as 18 minutes. Like all penguins, it uses its wings to propel its sleek body through the water.

Prions, small bluish-gray seabirds, skim krill and other small crustaceans off the top of the sea with their beaks. Fulmars, larger birds in the same family as prions, eat fish as well as krill and squids. Some fulmar species consume bird and seal carrion; the giant fulmar preys on eggs, chicks, and seal placentas.

An Antarctic penguin parade. Some penguin colonies number in the ten of thousands of birds.

Weddell seal and her pup. Weddell seals breed and pup around breathing holes in the ice.

The two species of Antarctic skuas prey on eggs and chicks of penguins and petrels. Skuas also pursue other sea birds and rob them of their catch. Most skuas nest near penguin or petrel colonies; those that don't find suitable nest sites near bird colonies may rely more heavily on fish and krill.

Krill, the center of Antarctica's food web, in their turn feed on phytoplankton, tiny aquatic plants, such as dinoflagellates and diatoms. Phytoplankton "bloom" in the summer in response to a combination of continuous sunlight and an upwelling of inorganic nutrients in the ocean. Krill then feed, grow, and multiply, supporting millions and millions of finely adapted birds, seals, whales, fish, and other animals that flourish around an icy continent that many imagine to be a remote and desolate wasteland.

Many also imagine Antarctica to be pristine and untouched by human forces. This, unfortunately, is not the case. The sheer number of animals has been no insurance against the negative effects of civilization. Remote as Antarctica is, its wildlife has already suffered significantly at the hands of the human race.

Some of the largest inhabitants of Antarctica's waters have been the hardest hit. Earlier this century, hunting reduced Antarctica's krill-feeding whale population by two-thirds, and almost eliminated elephant seals and Antarctic fur seals. While both seal species have rebounded, the whale population has been slower to recover. A recent count suggested that only 1,200 to 1,500 blue whales remain. Scientists estimate the pre-hunting blue whale population at 225,000.

Today, commercial fishing is threatening the backbone of Antarctica's food chain. The Soviet Union, Poland, Norway, Japan, and West Germany all fish for krill. In 1986, their combined catch totaled almost 500,000 tons. Compare this to the 115 tons of krill a year that all Antarctic birds eat, directly or indirectly. It's easy to see that a reduction in krill means a reduction in much of the Antarctic's wildlife.

The thinning of the ozone layer above Antarctica may be exerting another pressure upon the krill. Scientists have found that excess ultraviolet radiation coming through the ozone hole may slow reproduction in Antarctica's phytoplankton—the food source for krill. If this is the case, there may be less phytoplankton and hence fewer krill in coming years. Scientists think the thinning of the ozone is largely caused by chlorofluorocarbons (commonly known as CFCs), used in aerosol sprays, car air conditioners, and in the production of some styrofoam and electronic components. In light of this, two years ago 24 nations signed an agreement calling for a 35-percent reduction in worldwide CFC production by 1999. However, some scientists estimate that a CFC reduction of no less than 85 percent is necessary to stabilize the ozone layer over the coming century.

Ironically, scientists from nations all over the world have been befouling Antarctica and its wildlife while doing research there. In the summer of 1988, the Environmental Defense Fund reported that the careless practices of the National Science Foundation—including burning waste in open pits, dumping trash into McMurdo Sound, and running generators without emission controls—may have led to high concentrations of heavy metals and PCBs recently found in tissues of seals and penguins. The scientific bases of other countries engage in similar sloppy housekeeping. Most of the stations pile up their scrap metal and other trash along the shoreline—often in the midst of bird breeding colonies—and dump sewage and bilge into the ocean or lakes.

As if these problems weren't enough, the threat of mining and drilling for oil is looming in the future of Antarctica's animals. The original Antarctic Treaty, signed by 12 nations in 1959, promoted peaceful, cooperative, and scientific uses of Antarctica; it made no provisions for mining. Now, some nations, including the United States and Britain, want to ratify an international treaty that would allow mining. France and Australia have blocked the passage of this treaty, suggesting instead that the nations of the world proclaim Antarctica an international nature preserve. The Antarctic Treaty nations, now numbering 39, plan to meet in November in Santiago, Chile, to discuss both of these possibilities.

Because the continent is covered with ice, wells necessarily would be drilled offshore, among monstrous icebergs that may extend 600 to 900 feet below the surface and move up to 40 miles a day. To avoid being scraped away by the icebergs, drilling apparatus would need to be designed for operation deep under the water. In the almost inevitable event that these newly designed drills and pumps leak, or that a barge carrying oil be hit by an iceberg and spill its cargo, weather and ice would prevent effective cleanup, particularly in wintertime. An oil spill would certainly have disastrous effects on all the wildlife. In particular, oil mats the down of penguins and the fur of fur seals, destroying their ability to stay warm—and alive. Mining done on the continent itself most likely would destroy or disrupt breeding colonies of birds and seals. Enforcing environmental regulations would be difficult, if not impossible, on and around this barely accessible continent.

At this crucial juncture, we must ask ourselves: If scientists, many of them studying Antarctica's wildlife, have made such a mess, would oil and mineral companies be any more careful? With the world's new and all-encompassing environmental problems crossing man-made national borders, the establishment of Antarctica as an international park, where all wildlife and natural resources would be protected, would be a positive step toward global environmental cooperation.✤

Former ZooGoer *Assistant Editor Mary-Russell Roberson writes for North Carolina Alternative Energy Corporation.*
All photos courtesy of the National Science Foundation.

FRUITLOOSE

How Fruit Seeds Get Dispersed

Alexa Mergen
Illustrations by
Sriyanie Miththapala

When you visit the Zoo you probably see some of the animals eating. Many of the animals here, from bats to baboons, eat the same foods that we do, such as fruits and vegetables. The commissary, where all the food for the Zoo's animals is prepared, serves 41,600 pounds of apples, 20,800 pounds of oranges, and 7,800 pounds of grapes each year. Some animals, called frugivores, eat only fruit. The short-tailed fruit bats (*Carollia perspicillata*) in the Zoo's Bat Cave are frugivores. Fruits are essential to their survival. Fruits are also essential to the survival of the plants because fruits contain seeds.

Seeds are usually necessary for the growth of new plants. A seed does not grow well near its parent plant because the grown plants are likely to use most of the available sunlight, warmth, and water. Therefore, a seed needs to be moved away from its parent plant to a place where conditions are better for its growth. This movement is called dispersal.

Seed dispersal occurs by animals, by wind, and by water. Animals are important seed dispersers, spreading the new plants in many ways. Sometimes an animal carries a fruit

*Flowering dogwood (*Cornus florida*) is dispersed by animals.*

*Burdock thistle (*Arctium lappa*) has hooks that help disperse its seeds.*

*Dandelions (*Taraxacum officinale*) have seeds that are dispersed by wind.*

away from the parent plant to another location to eat it and drops the seeds when it finishes. Many primates and birds do this.

Fruits that animals, including humans, eat are usually fleshy, sweet, and brightly colored. These qualities have evolved to attract animals to eat the fruit. The flowering dogwood (*Cornus florida*) has brilliant scarlet berries that are eaten by squirrels, raccoons, and several species of birds.

Sometimes animals eat fruit, seeds and all. The seeds are later excreted by the animal after they have passed intact through its digestive tract. The short-tailed fruit bat is an extremely good disperser; a single bat eats and disperses about 3,000 fruits a night during the fruiting season.

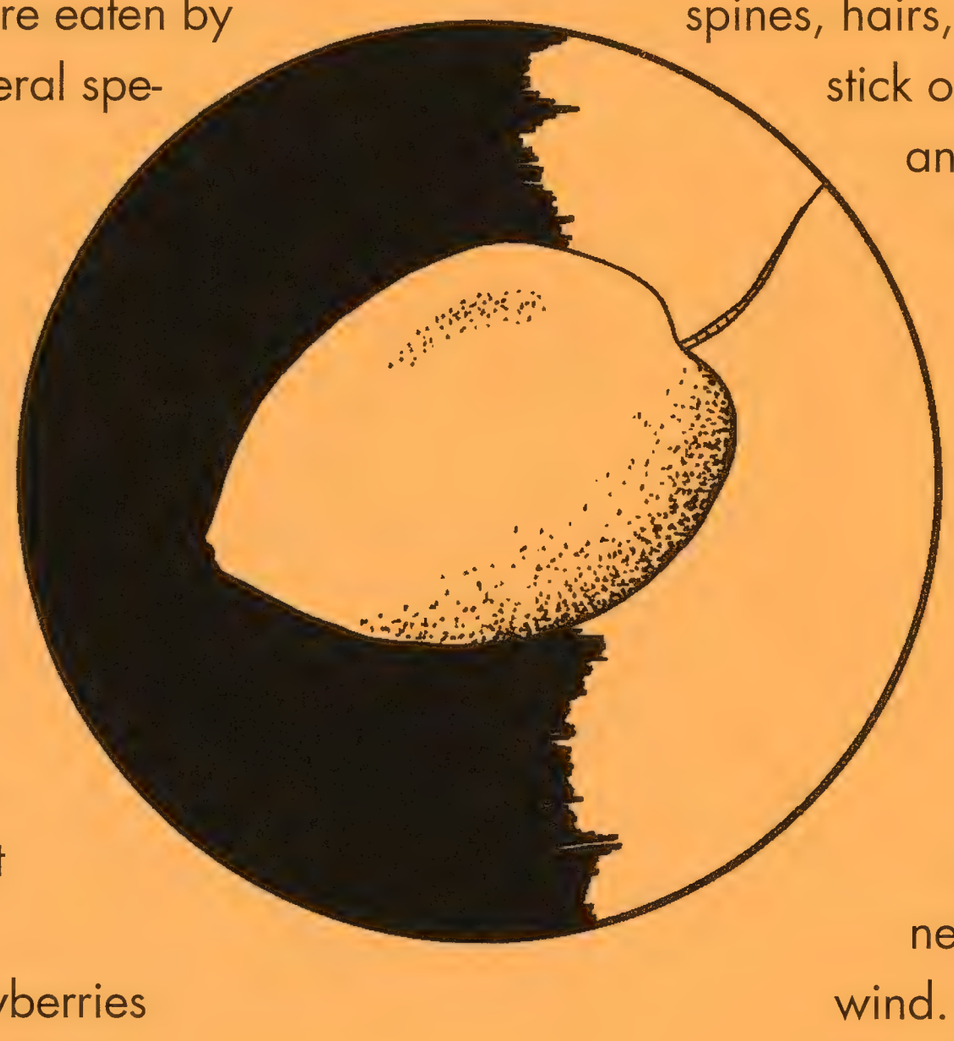
Fleshy fruits, such as strawberries and cherries, are well adapted to pass through an animal's digestive system—the hard seed coat is eaten away by enzymes, allowing the seed to germinate and grow. Scientist think a tree called *Calvaris major*, found on the island of Mauritius in the Indian Ocean, is now nearly extinct because its seeds need to pass through the stomach of a dodo before they germinate, and the dodo, a large, pigeon-like bird, is now extinct.

In its native Nepal, the greater one-horned rhinoceros (*Rhinoceros unicornis*) is one of the few animal dispersers of the Trewia tree. The seeds grow well in the rich rhino excrement. You won't see Trewia seeds in the Zoo's rhino enclosure, but you can look for whole seeds in the excrement of wild birds such as cardinals (*Cardinalis cardinalis*).

Besides a hard exterior, seeds can protect themselves in other ways. Some seeds, like apple and orange seeds, taste bitter to discourage animals from chewing them up as they eat the fruit.

Seeds don't always need attractive or edible fruit to be dispersed. Some fruits have evolved hooks, spines, hairs, and gooey substances that stick onto the fur and feathers of animals as they pass by. The burdock thistle (*Arctium lappa*) has hooks that help disperse its seeds.

The wind is a very good seed disperser. Tiny seeds of orchid fruits and spores of ferns and mosses are so light that the wind can carry them for very long distances.Some larger seeds need help to go blowing in the wind. Dandelions (*Taraxacum officinale*) have parachutes to lift them off their stems and scatter their seeds. Maples have even larger seeds, but they have wing-like extensions that help them to glide with the wind.



*The coconut (*Cocos nucifera*) disperses its fruit across water.*

Still other plants that grow near seashores or along rivers drift for long distances on the water. The oceans are very important dispersers of seeds to distant islands. One of the most useful plants in the tropics, the coconut (*Cocos nucifera*), spreads its floating fruit this way.

Nearly one-third of the plant species in the Hawaiian Islands came from mainland North America. Some drifted across the ocean or were blown in the wind, others hitched a ride with migratory birds, either nestled in feathers or carried in stomachs.

Match the type of dispersal to each fruit.

Eastern Cottonwood
(*Populus deltoides*)

____ Wind
____ Water
____ Animal

American Holly
(*Ilex opaca*)

____ Wind
____ Water
____ Animal

Red Mulberry
(*Morus rubra*)

____ Wind
____ Water
____ Animal

Red Mangrove
(*Rhizophora mangle*)

____ Wind
____ Water
____ Animal

White Ash
(*Fraxinus americana*)

____ Wind
____ Water
____ Animal

ANSWERS: Eastern Cottonwood—wind dispersed; American Holly—animal dispersed; Red Mulberry—animal dispersed; White Ash—wind dispersed; Red Mangrove—water dispersed.

Everything You Always Wanted to Know About Fruits But Were Afraid to Ask

As you've probably seen in the fruit department at your grocery store, not all fruits are alike. All fruits are fruits, some fruits are nuts, and some vegetables are fruits... HUH?

Okay, let's start at the beginning: A fruit is a mature ovulary, a case that contains one or more seeds. A simple fruit, such as a cherry, grows out of a single flower and a single ovulary. An aggregate fruit, such as a raspberry, develops from a single flower with several ovularies. A multiple fruit, such as a pineapple, develops from several flowers and several ovularies.

Fruits can also be grouped as dry or fleshy fruits. Dry fruits, in which the walls of the ovulary become hard, are called nuts. Fleshy fruits can be further grouped into three types: berries, drupes, and pomes. The seeds of a berry, such as a grape, are embedded in a soft pulp. By this classification system, tangerines and tomatoes are also berries!

Drupes, like apricots, usually have only one seed. In this kind of fruit, the outer part of the ovulary wall forms a skin, the middle part is pulpy, and the inner part forms a hard wall around the seed.

In a pome, only the core is the real fruit—surrounding the core is a fleshy portion formed from other parts of the flower. Apples are examples of this highly specialized fruit.

Now, try to match the type of fruit with each drawing.

Aggregate Fruit
Pome
Berry
Drupe
Dry Fruit

Grapes
(*Vitis*)

Pear
(*Pyrus communis*)

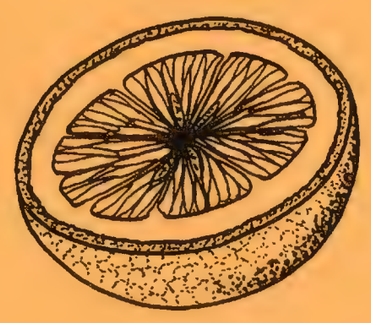
Peach
(*Prunus persica*)

Strawberry
(*Fragaria*)

Acorn
(*Quercus*)

Lemon
(*Citrus limon*)

Plum
(*Prunus americana*)



Orange
(*Citrus sinensis*)

ANSWERS:
Pear—pome
Strawberry—aggregate fruit
Plum—drupe
Grapes—berry
Peach—drupe
Lemon—berry
Orange—berry
Acorn—dry fruit

THE BEES FROM BRAZIL

Kathryn Barry

The honey bees collecting pollen in Texas fields this summer may look like southern drones, but they could be part of a bad- tempered contingent of African invaders. The dreaded "killer bees," which have been flying steadily toward the United States from South America for three decades, should cross the border at Brownsville late this year.

Scientists and beekeepers began buzzing about the bees when some African queen bees imported to Brazil from South Africa in 1956 escaped in 1957. Brazilian beekeepers had hoped to improve their European breeding stock with the African bees, which were better adapted to a tropical climate. What they didn't count on was that the bees—the African bees along with the hybrid young born from African and European matings—would take over.

But are the new bees really as dangerous as media reports and horror movies such as "The Swarm" have depicted? The sting of an African bee is no worse than the sting from any other honey bee—but the tendency of the bees to attack by the thousands understandably worries people.

African honey bees (*Apis mellifera scutellata*) belong to the same species as the honey bee that lives in the United States, which is actually a mixture of several European subspecies of *Apis mellifera*. African bees look like European bees, but react to intruders three times faster than European bees, attack in greater numbers, and will pursue intruders more than a half mile. The bees gained their "killer" reputation by killing hundreds of South American people and thousands of animals who unwittingly disturbed the wild bee colonies.

Thousands of bait hives like this one have been placed along Mexican highways to capture African honey bee swarms. (*Photo by Glenn Hall.*)

Each year, about 40 people in the United States die from allergic reactions to European bee stings. People who are allergic to bee stings can die after even one sting, while people without allergies have been known to survive up to 2,000 stings. Because the Africanized bees are more aggressive, they are more likely to sting people, and therefore are more likely to cause illness and death in those allergic to the stings. Even non- allergic people, especially small children, may die if they are stung by an entire swarm of bees.

Still, the scientists say that the public need not panic about African bees. "This is not going to be a major health problem. The very name 'killer bee' creates an image that is unjustified," says Orley Taylor, entomologist at the University of Kansas.

While experts generally agree that the public will not suffer greatly from the new bees, they have no such confidence about the beekeeping and agricultural industries that rely economically on bees. But no one can predict the degree of the bees' impact.

Preparing for the worst, the United States Department of Agriculture (USDA) predicts the new bees will cost consumers more than $100 million each year because of reduced honey yields, less effective pollination of crops such as almonds, apples, and citrus fruits, and increased cost of hive management because of replacing queens. The impact increases if estimates include the secondary costs of pollinating animal food crops such as alfalfa.

"Honey bee pollination affects every third bite of food that enters your mouth," says Janna Evans of the USDA's Animal and Plant Health Inspection Service. The pollination of crops largely depends on professional beekeepers who rent their hives to crop growers, often moving the bees across state lines. The USDA expects that some states will pass regulations prohibiting the transport of bees with African traits, curtailing the beekeepers' ability to provide pollinators in many parts of the country.

At the other end of the spectrum, researchers at Cornell University hold a minority view, anticipating minimal impact to agriculture by African bees. Scott Camazine, a Cornell graduate student who has studied the bees in Brazil, says these bees can take the place of domestic bees. He says Brazilian beekeepers have learned to work with the new bees and have developed a thriving honey and pollinating industry.

The differences in opinion arise from lack of scientific information on how the bees will respond to temperate climates. In South America, the bees have ravaged European bee colonies and proliferated widely in areas with a tropical climate similar to their African homeland. But no one knows how much the cold weather in the United States will slow them down, or how well they will compete with the well-established European bee colonies in the United States.

Scientists speculate that bees develop different behaviors to adapt to very different environments. In Europe, honey bees live in temperate climates with a predictable growing season, during which they must gather enough nectar to keep the colony alive over the long, cold winter. The African bees' tropical home sports a warm climate year-round, but the bees must contend with brief and unreliable nectar flows caused by variable, unpredictable rainfall. Birds, wasps, safari ants, honey badgers, and humans prey on the bees, often destroying the colonies. As a result, African bees store less food and emphasize rapid reproduction, frequent swarming, and aggressive colony defense. These behaviors serve the bees well in the wilds of Africa, but make them hard for beekeepers to manage in apiaries.

When wild African swarms move into an area where there is a European apiary, they take advantage of the normal bee behavior of changing queens. In all bee colonies, queens mate with a large number of drones from outside their own colony, a behavior that increases the genetic diversity of the colony. The more wild African bees in an area, the more likely the European queen is to mate with them and produce Africanized young that display aggressive African behaviors. South American beekeepers try to prevent the Africanization process by frequently replacing existing queens with fertilized European queens, a costly procedure that beekeepers in the United States may have to adopt when the African bees infiltrate the South.

Another complication is that most of the new bees will live as feral colonies rather than in managed apiaries. "It is barely known how to study, let alone predict the impact of, bees living in the wild," says David Roubik of the Smithsonian Tropical Research Institute.

Because Africanized bees compete for food and nesting sites that are used by some 10,000 Neotropical bees and a few thousand wasps, butterflies, beetles, and birds, Roubik says an equally significant impact is that the African bees will seriously disrupt local wildlife by out-competing the native animals that are now pollinating plants and trees. Roubik expects the Africanized honey bees eventually to displace, by competition, many native species of flower visitors. Because the Africanized bees can potentially alter the repro-

duction of roughly half of all tropical flora, the bees' presence can seriously affect the animals that feed on seeds, fruit, and foliage.

Roubik says popular prejudices and misconceptions about bees—that they are here on earth for man's use, that they live naturally in hives (which are actually human-made boxes), and that they are temperate-zone animals—have focused attention on their economic impact while ignoring the bees' impact on natural ecosystems.

The dearth of natural history research leads to the most controversial issue: What to do about the bees?

The USDA has launched an all-out effort to keep the bees from the United States. Baiting 30,000 traps with bee pheromones, the USDA is trying to capture and kill as many African and hybrid bees as possible in Mexico. The USDA encourages Mexican beekeepers to destroy their hives when they discover Africanized bees in them; but neither the USDA nor the Mexican government offers the beekeepers financial compensation for the lost hives, and beekeepers have been reluctant to comply.

The USDA also hopes to dilute the bees genetically by flooding the Mexican skies with European bees at strategic points, anticipating that the tamer drones will mate with the northward-flying queens to produce a more "Europeanized" bee by the time the bees reach the States.

Other researchers doubt the USDA will be successful in preventing or altering the bee migration. Genetics research conducted by Glenn Hall at the University of Florida indicates that while most northward-migrating bees are hybrids between European and African subspecies, the contributions from each are not equal—the genetic makeup of the population is almost completely African. Furthermore, researchers at the University of Michigan and the University of Kansas found that wild colonies headed by European queens usually do not survive, which suggests that the USDA's dilution strategy would not work, at least in the tropics, where African queens have an ecological advantage.

H. Allen Sylvester of the USDA Agricultural Research Service questions the genetics research because the geneticists examined only one type of DNA—mitrochondrial DNA, which is passed on only from the mother—rather than chromosomal DNA, which offspring inherit from both parents. He says it will take more research to determine the degree of hybridization of the migrating bees. Hall agrees that the mitrochondrial research cannot determine the degree of hybridization. However, he says that he has submitted new research on chromosomal DNA that also shows that African bees are not breeding much with European bees.

Nature may solve some of the problems without any human interference. "In the USA, I believe the African bees will be at an ecological and genetic disadvantage. The African bees will have European competition just south of the border—there are many feral colonies between Tampico, Mexico, and Brownsville, Texas. This is the first time that has been the case—tropical America had essentially no Apis in the wild, ever," Roubik says.

But in subtropical climates, such as southern Florida and Louisiana, Roubik predicts the African bees are likely to thrive and will require permanent human management. A pilot study in the Panama Canal region—an area with an environmental and social setting similar to that of the southern United States—supports Roubik's prediction. Africanized bees first arrived in Panama in 1982. As expected, the large bee swarms alarmed area residents, injuring a few people and killing animals. Many colonies built nests in public structures such as buildings, utility manholes, and air-conditioning ducts. Government agencies implemented an intensive education campaign, including public briefings and media announcements, which helped reduce the number of injuries. The Panama Canal Commission destroyed 1,175 colonies of Africanized bees. Nevertheless, aggressive Africanized bees still survive in Panama despite on-going control efforts.

Most researchers say that humans—not the insects themselves—will determine the extent of the impact of Africanized bees in the United States. "Bees are a lot more predictable than human beings, and easier to deal with than people," says Orley Taylor, entomologist at the University of Kansas. He predicts public outrage if, for example, the bees should hurt a child soon after they arrive in Texas. But if the bees don't hurt anyone for decades, Taylor says the public will realize that the bees aren't a serious public health threat.

One strategy that experts agree will help—though no one knows how much—is education. Educators in Panama tell people to leave the bees alone, and emphasize that the African bees are wild rather than managed in apiaries. The USDA is distributing a series of brochures on bees and beekeeping to educate both professionals and the public in the southern U.S.

H. Allen Sylvester says the official USDA stance is that the bees are a problem and should not be ignored. "On the other hand, we don't want people to be terrified. People will not have to give up living outside because Africanized bees are living out there." Sylvester says to treat strange bee swarms just like a hornet's nest—leave them alone and call an exterminator.

People who keep bees as a hobby may decide keeping the new bees is just not worth the risks. But Camazine of Cornell predicts that there might be a new generation of beekeepers: "Maybe they'll be a little more macho, and will want to sell African bee honey."✤

Kathryn Barry is a Seattle-based science writer who interned at ZooGoer *in 1989.*

Zoo Bees

Across from the white-tailed deer exhibit, the National Zoo displays the inner workings of a beehive. The Zoo's bees (*Apis mellifera ligustica*) come from Italian stock, and share the characteristics of the common European bees that roam freely in the United States. They are excellent honey producers and pollinators, have good resistance to several common bee diseases, winter well in cool climates, and are generally easy to manage. Look for the queen bee—she's marked in the exhibit.

(Photo by Chris James.)

SEX AND SURVIVAL IN BADLANDS BISON

Carol Cunningham and Joel Berger

On a scorching summer day, the Badlands of South Dakota seem very aptly named. Like the draft from a fire, the prairie wind parches the sod tabletops and pockets of grass. Stark buttes and pinnacles, their outlines slightly blurred by the haze, pierce an immense sky, and nothing seems alive but the grasshoppers, sweat bees, and biting flies. To look at North America's largest prairie national park on such a day, and to remember its other extremes of climate—ferocious blizzards and temperatures far below zero—one might not realize that it supports deer, pronghorn, bighorn sheep, and one of the last herds of bison.

*For many people, bison (*Bison bison*) are the animals that best represent the prairies, the Old West, and the traditional Plains Indian cultures. The American settlement of the West a century ago nearly exterminated a species that in historical times lived from Mexico to New York and Oregon north to the Yukon and Alaska. Only 100,000 bison still exist. As with many species whose habitats have been sacrificed in the name of "progress," we will never be able to understand the bison of the past, either as migrants across vast prairies or as inhabitants of southwestern deserts or eastern deciduous forests. Fortunately, some aspects of bison biology, such as their social behavior, should be relatively insensitive*

Bison are social animals and tend to live in groups. *(Photo by Joel Berger.)*

A yearling bull smells a female to determine her reproductive condition. *(Photo by Joel Berger.)*

to changes in the physical environment and can still be studied in preserves and national parks.

The Smithsonian Institution and, in particular, the National Zoo have had a long-standing, indirect association with North American bison. The Henry Mountains in southern Utah, the home of a little-known but totally free-ranging (unfenced) bison herd, bear the name of Joseph Henry, the first Secretary of the Smithsonian. One of the Zoo's founders, William T. Hornaday, was among the few people of his time active in saving bison from extinction. In the 1880s he traveled to the Badlands of central Montana to procure specimens of bison for taxidermy but, seeing their rarity, returned with the idea of preserving live bison and other endangered species in a national zoo. Subsequently, live bison were displayed on the Mall in Washington, D.C., in a successful test of their public appeal prior to the founding of the National Zoo (*ZooGoer* March-April 1989).

Among national parks such as the Badlands, Yellowstone, and Alberta's Wood Buffalo, environments vary in predation pressure, openness of habitat, and distribution of food and water, but there are few differences in bison social behavior. Large groups of cows assemble in open areas after their spring calves are born, and males join these aggregations during the summer breeding season. As the largest terrestrial mammals in the New World, bison must spend a great deal of time feeding, and this has led some people wrongly to assume that they are docile, non-competitive animals. In truth they are active competitors.

Bison are among the most sexually dimorphic of ungulates. Males, some of which weigh over a ton, are twice as heavy as females, and also have larger horns, thicker beards, and longer foreleg hair, or "pantaloons." Such differences in secondary sexual characteristics often relate to mating behavior. More than 100 years ago, Darwin noted a relationship between animal polygamy and the development of secondary sexual characters, and Dale Lott of the University of California at Davis has shown that male bison breed with numerous females in a season. Choosing multiple mates puts bulls in more competition with each other, and they may use distinctive anatomical features for display or fighting, Lott suggests. To us, this sexual dimorphism in bison made them good subjects on which to test another idea from Darwin about dimorphism: that conspicuous anatomical adornment in the males of a species means that the females are more selective than the males in choosing mates. Perhaps male bison used distinctive characteristics in order to attract cows. We chose bison as our subjects also because their prairie habitat makes them comparatively easy to observe. The relative lack of human interference at Badlands National Park made it our choice of study site.

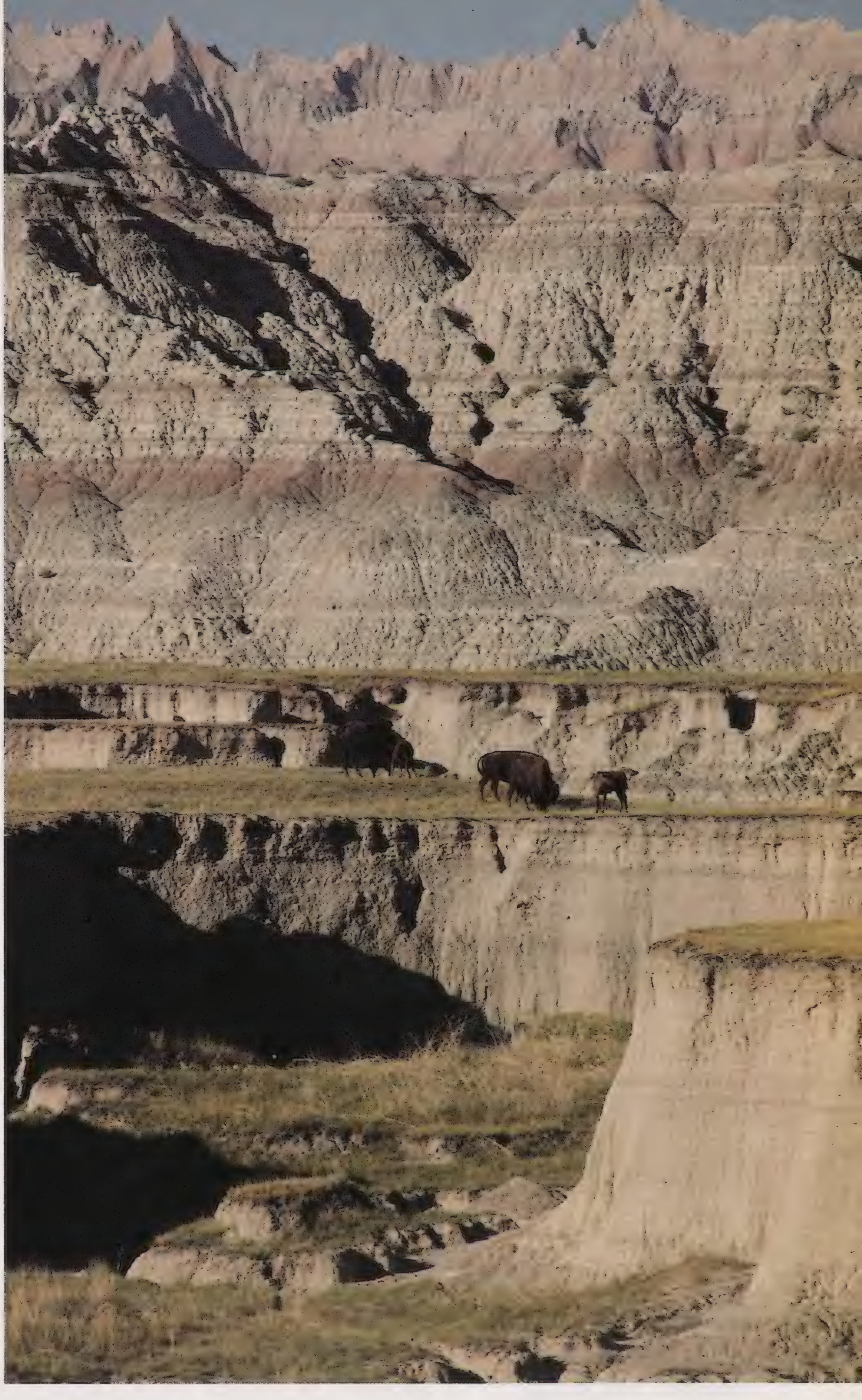
However, as time went by and our observation hours increased, we wondered more about how males selected females. Overall, the Badlands population increased from about 300 to 775 animals between 1985 and 1989, but not all cows reproduced equally. Although larger cows are usually more fertile, some cows that weighed more than 1,200 pounds never produced a calf, whereas others that weighed only 1,000 pounds had a calf every year. Obviously, size was not the only factor in cow fertility. Furthermore, if females varied so much in their reproductive potential, it would make sense for males to identify the most fertile cows when selecting mates: We wanted to find out whether and how males selected females, as a bad choice could result in no offspring or offspring with a poor chance of survival.

First we had to determine what made an adult female (three years or older) more likely to produce a calf the following year. We found that females without a calf, which we designated as "barren" for that year, were more likely to bear young the following year than were those females that were currently nursing a calf. Barren cows were heavier, healthier, and receptive to males earlier in the breeding season than were lactating cows. Of course, earlier mating means that young are born earlier in the year and thus have time to gain the weight that will increase their chances of surviving the harsh winter.

Badlands bison are scattered across more than 100 square miles of buttes, pinnacles, and grasslands, and individuals join or leave groups at will. Aggregations vary in size throughout the year from as few as two animals during the non-breeding season to as many as 450 in a single area during the summer rut; breeding groups usually number from 200 to 300. Most bulls emerge from their winter ranges in June or July to search for groups containing estrous cows, but a few pass through female groups, showing signs of interest, as early as May. Possibly the bulls that arrive early are those best able to locate estrous cows and minimize their own losses in body condition. Locating and mating with females during the rut is physically grueling for males: They may lose up to 300 pounds from traveling as far as 17 or 20 miles a day in 108-degree heat and from reducing their feeding by as much as 90 percent. The amount of time that males spend at the rut clearly shows how exhausting it is. During the first half of the rut, bulls six years or older spend an average of only about eight days with cows, even though the breeding period spans approximately six weeks. The strenuousness of mating makes it important that males not waste their strength on females that will probably not bear young.

If males are selecting their mating partners, opportunities must arise when they can clearly make choices. Although a few bulls appear when only the biggest, barren, and potentially most fertile cows have come into estrus, arrival time is not a convincing demonstration of choice. We needed to observe the interactions among the majority of bulls and cows to determine how they choose their breeding partners. We found that males do have an opportunity to choose among different kinds of females when barren cows, lactating cows, and young females in the same

Fighting is one way bulls ultimately choose their mates. *(Photo by Carol Cunningham.)*



Bulls join the cows and calves in large and open areas in time for the summer breeding season. *(Photo by Joel Berger.)*

group come into estrus on the same day.

The young females, of which only about one in six produced a calf annually, should have been least attractive to males, and males did in fact approach them least often when other cows were available. About 90 percent of barren cows bore young the following year, and logically the bulls most preferred them. Surprisingly, although only about 30 percent of lactating cows had calves the next year, bulls favored them almost as much as barren cows. For the most part, males made the same choices regardless of their age, although young breeding males less often approached barren and lactating females that were guarded by older males.

While the rut of bison is very chaotic—bulls urinate on themselves, wallow, bellow, fight, and then roam widely in search of cows—we could nevertheless clearly tell that males choose their mates fairly carefully on the basis of reproductive potential. But what about our original hypothesis, based on Darwin, that cows were probably more selective than bulls? Unfortunately, we could find no evidence either way. Estrous females, when guarded by small males, sometimes run more than four miles in 30 minutes, apparently to attract the attention of males and incite competition among them. Although cows do not directly approach larger bulls, the physical condition of bulls changes so quickly during the rut that it is hard to say whether size affects their attractiveness or not. Even if females do discriminate at least as carefully as males, they are at any rate less obvious about it.

We cannot be sure whether our findings about Badlands bulls hold true for bulls on other reserves. Badlands bison roam freely within a national park, but at reserves like Witchita Mountains in Oklahoma, the National Bison Range in Montana, and Fort Niobrara in Nebraska, bison populations are maintained at fixed levels to avoid damage to their habitats. There males cannot search large areas for females, and both sexes, because of human-imposed grazing systems, have grass in great abundance. As a result, 80 to 90 percent of the females on managed reserves bear young each year and they vary less in their reproductive potential than the females at Badlands. Where cows differ so little, it may not be worthwhile for bulls to be so particular. Of course, while Badlands bison can range more widely than bison in managed reserves, they do not have complete freedom to travel. As at Yellowstone or Wood Buffalo parks, animals that stray outside the park often get killed. Hence we cannot know how far bison would travel if left to themselves and how this would influence mating patterns.

While we still do not know exactly how an individual bull selects an individual cow, we do know that bison are amazingly hardy and resilient beasts. They have outlasted many species with which they shared the North American continent in Pleistocene times, such as dire wolves, lions, horses, camels, mammoths, and mastodons, and have survived near-extermination by American pioneers in the recent past. In all times they have had to endure searing summers and winter blizzards. Nowadays, with the aid of both human management on reserves and their own careful selection of mates, bison seem likely to roam the prairies for a long time to come.✤

Carol Cunningham is a field-working, data-crunching free-lance writer who has worked on diverse projects involving horses, bison, and black bears.
Joel Berger is a Smithsonian Research Associate and a Professor at the University of Nevada-Reno Program in Ecology, Evolution, and Conservation Biology.
In 1991, they will begin a three-year field study of black rhinos in the Namib Desert.

Siberian Ferrets: Getting Ready For The Wild Life

Veteran Zoo visitors accustomed to watching the antics of prairie dogs at the lower end of the Zoo have been surprised by new residents in the enclosure: a pair of Siberian ferrets (*Mustela eversmanni*). Native to the unwooded, open steppes and semideserts of the USSR, Mongolia, and China, these ferrets are VIAs (Very Important Animals) at the Zoo these days, because in addition to their exhibit duties and the oohs and aahs they elicit from onlookers, they are helping Zoo scientists learn more about one of North America's most endangered animals, the black-footed ferret.

Siberian ferret at the Zoo. (Photo by Milton H. Tierney, Jr.)

The graceful, reddish-brown Siberian ferret, a member of the Mustelidae (the weasel family), is the black-footed ferret's closest living relative. The two species are similar physically as well as in their ecology and behavior. Brian Miller, an NZP Conservation and Research Center scientist and black-footed ferret expert, explains that the Siberian ferrets are excellent substitutes for the black-footed ferrets. Many procedures for black-footed ferret training and reintroduction programs are given a dry run with their more prolific, non-endangered Siberian relatives. Robo-badger (the radio-controlled, stuffed badger on the motorized undercarriage of a toy truck), used to introduce black-footed ferrets to their natural predator was tested first on the Siberian ferret, as was a stuffed great horned owl suspended on a string. Miller notes that it took only one "close call" for the ferrets to understand the potential danger. Later this year, neutered Siberian ferrets will be introduced to potential black-footed ferret habitats in the western U.S. as a rehearsal for the release of the endangered North American ferret in 1991.

Now that the prairie dogs have been removed from the exhibit near Monkey Island, the ground is covered by a dense growth of grass that affords a rich source of cover for the ferrets. Visitors must look closely to find the two new inhabitants. (The larger one with the chubbier face is the male.) Patient observaton is rewarded with a glimpse of the sleek animals as they undulate through the grass, occasionally standing up to sniff the air and to get a better view of the surrounding territory. They have a well-developed sense of smell and very sharp teeth, characteristics that in the wild equip them to hunt for small rodents found in abundance on the steppes. The ferrets, which have light masks around their eyes and creamy tipped ears, are frequently seen in the mid-morning, or whenever keeper Brenda Morgan appears with pans of their food, a mix of mink and mice chow. On hot days, they tend to spend more time in their subterranian burrows to escape the heat.

John Seidensticker, Curator of Mammals, says the ferrets are frequently observed slithering over the burrow entrances, dragging their tummies over the mounds. He explained that the ferrets use abdominal glands to scent-mark and establish their territory. He notes that when the ferrets were first introduced to the enclosure, they were "extraordinarily busy" marking it as their home.

The ferrets move quickly, dodging in and out of the holes, some of which are left over from the prairie dog days. The ferrets are good diggers, though, and have already excavated their own holes, mostly near the edges of the enclosure.

Morgan, who has been caring for the ferrets since they arrived this past May, says that when she feeds them mice, the male surfaces quickly and hides all of the tasty rodent tidbits throughout the enclosure. The female is not to be out maneuvered: After the male leaves the scene, she appears, sniffs out the hiding places, and transfers the mice to her own secret caches.

The ferrets are rather curious, and Morgan warns they are apt to snatch anything an unwary visitor may leave dangling over the side of the enclosure. One little girl, visiting the Zoo on a school outing, was very much surprised when she saw her small coin purse disappear into one of the many holes.

Prairie dog aficionados need not despair for the lively little rodents. Seidensticker expects to have another colony ready to exhibit in the fall.

—Margie Gibson
NZP Staff Writer

Racetrack Cleanup

More then 100 volunteers from the National Zoo, the National Aquarium in Baltimore, and the Baltimore Zoo raised more than $5,000 for rainforest conservation by cleaning Pimlico racetrack on May 20. The money raised purchased 40 acres of South American rainforest land for permanent protection through the Nature Conservancy's Adopt-An-Acre Program.

Approximately half the money raised by the National Zoo and Greater Baltimore chapters of the American Association of Zookeepers came from a contract with Harry M. Stevens Maintenance, Inc. for cleaning the field. Volunteers raised another $2,440 by recycling the 160,000 aluminum cans they collected.

People wishing to join the FONZ members and FONZ volunteers who participated in this year's successful cleanup should watch for upcoming announcements of next year's event in *Wildlife Adventure*.

Lectures at the National Zoo

On Wednesday, August 15, there will be a free slide show and lecture on **Birds of the Tropical Rainforest**. The evening lecture, sponsored by the Resident Associate Program, NZP, and the World Wildlife Federation will be held at 7:00 p.m. in the Education Building. For more information call Michael Caplin at 357-1435.

David Adamski will give a free lecture Tuesday, August 20, on **Wildlife in the Seychelles and on Aldabra**. The Seychelles are of great interest because of the unique biota found on these islands: giant land tortoises, tree frogs, caecilians (tropical burrowing amphibians resembling worms), and fruit bats. Call 673-4789 for information.

On Wednesday, September 12, John Boshe of the World Wildlife Fund will give a free lecture on East Africa. For information contact Lynn Baptista at 778-9503.

On Monday, October 1, Irene Pepperberg of Northwestern University will give a free lecture on animal intelligence. Call 673-4789 for information.

New at the Zoo

The cries of crested screamers, a bird species returning to the Zoo after a long absence, are drifting across the Park this summer, harmonizing with the melodies of other birds and the sounds of the wind riffling through the tall grasses of the Wetlands area.

As their name suggests, crested screamers (*Chauna torquata*) are vocal birds. Their native marshland habitat in South America often resonates with their piercing, trumpet-like warning calls and melodic songs. The best time to hear the Zoo's feathered Pavarottis is mid-morning, just as the sun breaks above the surrounding trees, says bird keeper Liz Glasgow.

Crested screamers are native to the pampas and subtropics of Brazil, Uruguay, eastern Bolivia, and Argentina, where they are found grazing on aquatic plants around lakes and marshes. They're large birds, weighing five to six pounds, and on a steamy summer day in Washington they look even heftier as they fluff out their feathers to insulate themselves against the heat. A cowlick of feathers crowns the back of the screamer's head and a narrow ring of black feathers forms a natural necklace around its stocky neck. Red markings encircle the eyes. Orange legs about 18 inches long elevate the majestic gray birds above the water level of their swampy habitat. Unlike most waterfowl, screamers have very little webbing in the feet, an adaption that allows them to walk easily through swamps and to perch in trees.

Screamers have two spurs, one- to two-and-a-half inches long, on the leading edge of each wing. Spurs are primitive structures, more commonly found in the fossil record than in modern birds. In the wild, crested screamers use the spurs to fend off potential predators. Another unusual feature of screamers is a layer of small air cells between the skin and muscle throughout the bird's body. These air sacs create a rumbling, crackling noise as the birds take off, but their function is unknown.

Piles of grass have been heaped at the rear of the exhibit by Glasgow and other keepers in hopes of gently nudging the avian couple toward mating and nesting. But so far, the screamers have remained oblivious to these matchmaking efforts. Should they eventually cooperate, the Wetlands area will provide them with a rich supply of plants and sticks to use for nesting material.

Another new Zoo species, magpie geese (*Anseranas semipalmata*), reside at the waterfowl pond between the Wetlands and the Australia Pavilion. They are easy to identify, with black and white plumage reminiscent of their magpie namesake. The black feathers on the head, neck, upper shoulders, and tail contrast sharply with white feathers on the rump and belly. The male goose is the one with the knobby head, a natural development as the bird ages.

Like screamers, magpie geese have just a small amount of webbing in their feet. They also have large hind toes, useful in hanging onto branches, and a hooked bill that resembles a chicken's beak.

The magpie goose's natural range is the swamps and flood plains of the northern and

Crested screamer.
(Photo by Chris James.)

northeastern Australian coasts. Before 1900, the geese were widely distributed, but hunters, farmers, and habitat destruction have reduced the once-abundant flocks.

From March to May as the rainy season ends, the magpie geese breed in rice fields, preferring man-made paddies over wild fields. To the dismay of farmers, the birds' nesting and feeding habits destroy the cultivated fields. Invading flocks feast on the rice and trample and tear off the stalks of the tender plants to form their nests. To protect their crops, farmers began poisoning the birds.

But with a better understanding of the birds' habits, came an armistice in the farmer-magpie goose war: Farmers learned that the birds are very particular about the water depth in nesting areas and so they started keeping water in their rice fields shallower than the birds required. Thus, the magpie geese were forced to return to the deeper wild lagoons for breeding.

—Margie Gibson
NZP Staff Writer

Annual Meeting

Watch your September mail for your invitation to the FONZ Annual Meeting on Thursday, October 18. Following installation of new FONZ officers and a review of FONZ's accomplishments in 1990, there will be a special ceremony to dedicate "Volunteers," the exquisite tree sculpture by Steven Weitzman. Two years in the making, "Volunteers" was commissioned by FONZ and the Zoo to honor the hundreds of volunteers who for so long have done do so much for the Zoo. The reception, business meeting, and dedication will take place in a tent on the Great Meadow and special animal activities in nearby exhibits are planned.

Oops!

In the May-June *ZooGoer* article, "The Zoo Biology Training Course in Guatemala City," instructor Jacques Prescott was incorrectly identified. Prescott is General Curator at the Jardin Zoologique du Quebec. We regret the error.

Saguaro #2, *by William M. Sullivan. Courtesy of Sherry French Gallery.*

Outposts of Eden:
A Curmudgeon at Large in the American West.
1989. Page Stegner.
Sierra Club Books,
San Francisco, CA.
226 pp. hardbound,
$17.95.

I sometimes think that nature writing, like classical music, is a taste I will never acquire: no matter how magnificently crafted, I'm afraid it will put me to sleep. A sweeping prejudice, but it keeps me from venturing beyond a book's dramatic cover to explore the landscape of the text inside. Happily, I was drawn by my worst instincts to the subtitle of Page Stegner's *Outposts of Eden: A Curmudgeon at Large in the American West* and discovered a terrific book that shattered my stereotype. *Outposts of Eden* is nature writing with a bite—a collection of gritty meditations on the erosion of the lands and spirit of the western states.

Declaring himself "another grumping environmentalist," Stegner describes and rabidly defends a range of fragile environments that have suffered at human hands, either from too much love or not enough: the tourist-choked Grand Canyon on Memorial Day at one extreme, and the Mojave Desert at the other, misperceived as a four-hour wasteland between casinos and resorts, and best written off as a giant playground for weekend armies of off-the-road vehicles. Stegner's sensibility is as harsh and thorny as the landscape he loves; his acid humor seems to go with the territory.

If the point of view sounds negative, it is, and with some reason. But the essays are also energetic, reverential, and inspiring. Stegner's depictions of desert scenery literally sizzle, his prose is always entertaining, and his outdoor adventures gone awry are hilarious.

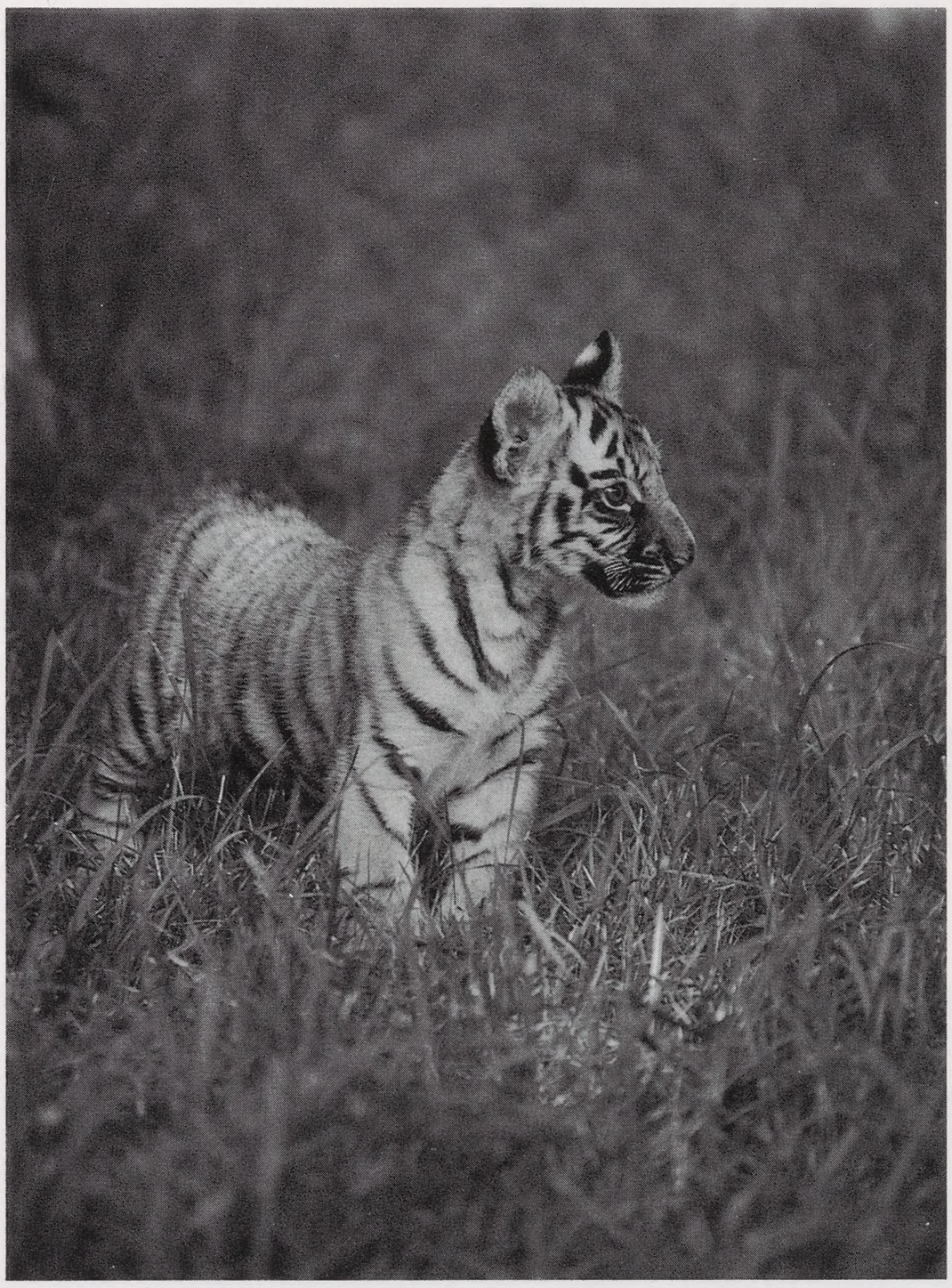
The author is at his cynical best, however, when he turns his hawk eye from the vegetable and mineral scene to the varied species of human fauna that have become an integral, even pivotal, element of every American ecosystem. Stegner finds blame enough for the West's decline to go around, and he indicts virtually everyone up and down the political scale. A favorite target is the Federal agencies responsible for managing public lands—the one-third of America that is every taxpayer's backyard. As Stegner and a host of other environmental watchdogs see it, the agencies' pro-business policies subvert the mandates of their original charters. On the far left end of the spectrum, Stegner nails the knee-jerk extremism of eco-groupies, who toe a radical party line while giving short shrift to actual experience of the nature and culture for which they claim to speak.

Falling somewhere in the middle is the evil banality of rural gentrification, as yuppies, crowded out of the suburbs by costs and traffic congestion, migrate to towns like Aspen, Taos, Santa Cruz, and other doomed-to-be-discovered "outposts of Eden." Changing locations without lifestyles, they quickly homogenize these areas with the amenities of home. Stegner charges these upscale migrants, along with their less well-meaning corporate counterparts, with hastening the collapse of the countryside and the agrarian culture it supports—a culture based on exploiting the forests and waters, but with enough sense of self-preservation to conserve the resources that provided livelihoods.

Finally, relentless critic that he is, Stegner turns the spotlight on himself, tallying the ever-escalating costs of his bungled attempts to get back to nature suburban-style and live off the fat of the land.

Well-known for his books and articles on the state of the West, Stegner is an author whose work fires both political spirits and imagination. His is nature writing that rouses, and makes you long to hit the trail.

—*Susan Weinberg*



The world's first test-tube tiger. (Photo by Jeff Tinsley/Smithsonian Institution.)

Unnatural Selection

Ann Miller's pet "George" is the only one of its kind on earth. He looks like any other kitten, but George was created with the help of fiber optics and sophisticated reproduction techniques that Miller helped develop at the Zoo. "Mary Alice" is another one-of- a-kind cat: the world's first "test-tube tiger." Born in April, Mary Alice is the offspring of the intensive research efforts of scientists at the National Zoo's New Opportunities in Animal Health Science (NOAHS) Center and their collaborators at the Henry Doorly Zoo in Omaha and the Minnesota Zoological Gardens in Minneapolis.

While artificial insemination has long been commonplace in the breeding of cattle, and human "test-tube" babies no longer cause sensation, only recently have Zoo scientists made the transition to applying these technologies first to domestic and then to small wild cats. The first kittens were produced from in vitro fertilization at the National Zoo in 1987 by Karen Goodrow, then a student in the Zoo's Reproductive Physiology Program. But only now have scientists learned enough about feline reproductive physiology to practice tiger matchmaking in a petri dish. All of this is the result of more than a decade of research, funded in part by FONZ, by a team of scientists working in the Department of Animal Health, led by Reproductive Physiologist David Wildt. According to Wildt, "The birth of Mary Alice was a crowning achievement as well as a spur to even greater efforts."

The importance of the achievement lies in the future health of zoo populations of animals—in particular, endangered species for which animals in zoos may outnumber those in the wild. In order to maintain the largest possible gene pool in a small, endangered population, zoos strive to manage the offspring by mating those individuals that are most distantly related or not related at all. (In general, animals kept in zoos are descended from limited groups of "founding members": the original animals brought into zoos from the wild.) Sometimes this is impossible. Genetically ideal mates might live in zoos half a world away from each other and the stress of a long journey could preclude any hope of natural conception. And the best genetic coupling might not prompt the animal's desire; tigers, like humans, prefer to choose their own mates.

Artificial reproduction does away with such concerns. With advanced freezing techniques, sperm as well as fertilized embryos may be stored and shipped relatively easily. Researchers eventually hope to draw upon wild populations, without removing the animals, to bolster limited zoo gene pools.

Mary Alice's conception was decidedly unromantic. At the Henry Doorly Zoo, scientists prepared four tigers for three different procedures: two female Bengal tigers to provide eggs, one male Bengal to contribute sperm, and a female Siberian to act as surrogate mother and carry the cubs to birth. The biological mothers received hormones to enhance the ability of their ovaries to produce mature, fertilizable eggs. The tigers' ovaries responded by forming follicles—fluid-filled blisters covering the surface of the ovary, each of which contains a mature egg. Using a laparoscope, a long, thin metal tube containing a fiber-optic cable, scientists were able to keep a close eye on their work while they inserted a needle into each follicle and extracted the liquid and egg inside.

Meanwhile, the semen from the male Bengal was spinning away in a centrifuge to separate the sperm from its surrounding liquid. Once all the sperm were isolated in the bottom of a tube, it was a relatively simple matter to distinguish the normal from the abnormal. The sperm that managed to swim up through a thick solution in an hour or so made the cut.

(In some endangered populations, notably the cheetah, the animals are so inbred that great percentages of sperm are abnormal. Defects such as misshapen heads, bent midsections, or coiled tails all impede the sperm's ability to fertilize an egg.)

The researchers allowed the fertilized tiger eggs to incubate for about two days in a medium containing vitamins, amino acids, sugars, and salts to see which embryos would sucessfully develop. From those, 12 to 15 embryos were selected and surgically implanted into the oviducts of the surrogate mother. (This was the researchers' second attempt at implanting embryos in tigers; none of five potential surrogate mothers became pregnant on the first try.)

At this point, Mary Alice's origins diverge from George's. While the tiger embryos were transferred into the oviducts of the reproduc-

tive tract through an incision in the abdominal wall, the embryonic kitten traveled directly to the uterus via the laparoscope. Because only a very small puncture is needed to insert the instrument, laparoscopic transfer is much less traumatic to the surrogate mother. George is the first of what scientists hope will be many cats, including his large cousins, produced in this way.

Though the preliminary research was performed in the lab, the Zoo scientists eventually had to bring their technology to the tigers. Miller and her co-worker Leslie Johnston thus pioneered a Mobile Lab to transport delicate equipment such as ultra-thin pipettes whose ends are little larger than a tiger egg, fragile fiber-optic cables, and easily contaminated culture media.

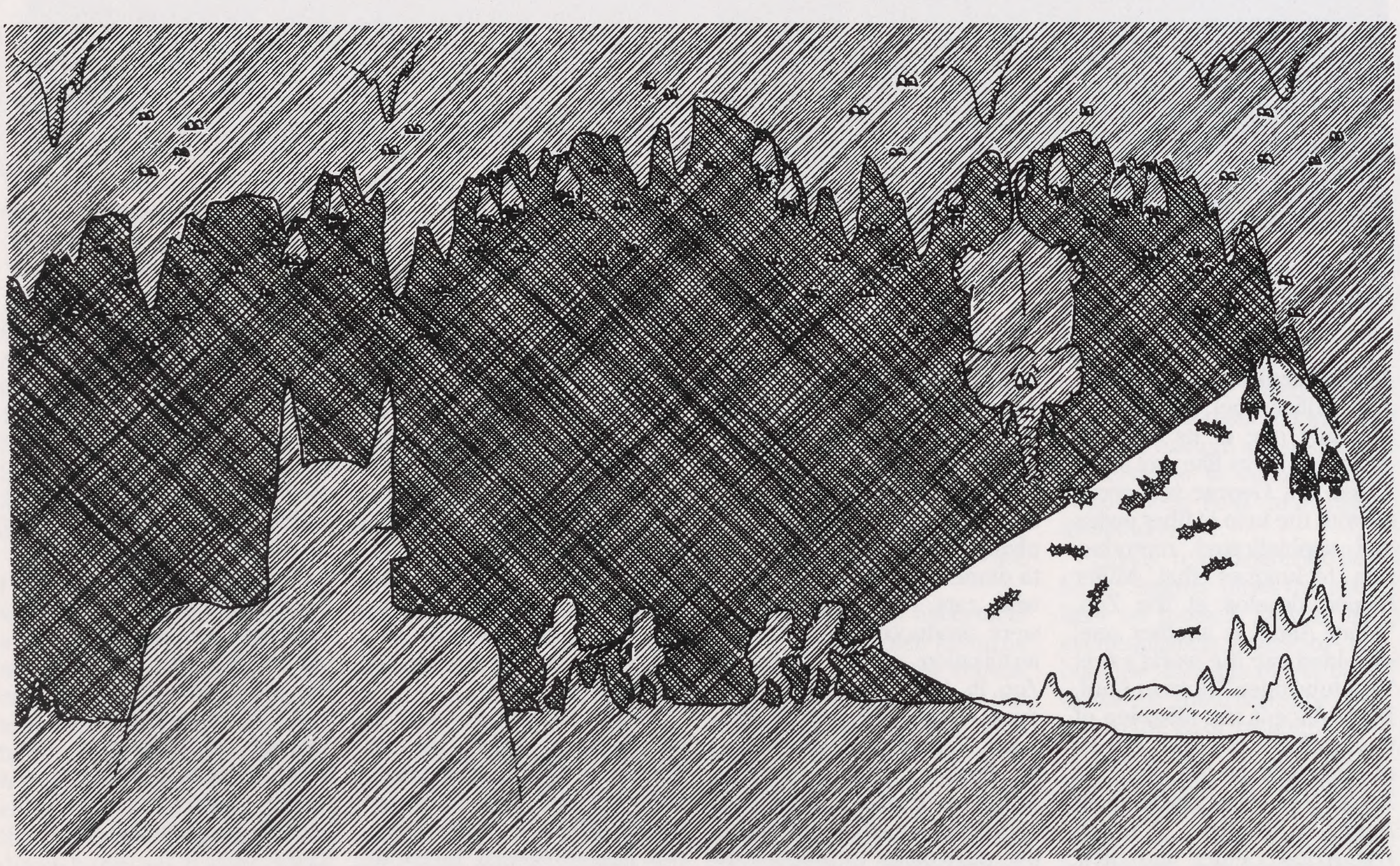
The rewards so far have been great. Much of the tigers' reproductive physiology remains unknown, but researchers now have pinpointed details such as the quality of sperm necessary to penetrate an egg, and the time window during which the eggs are receptive to fertilization. These precise new techniques also require a much smaller sperm-to-egg ratio than artificial insemination, the technique farmers routinely use to boost meat and milk production in cattle, but which requires millions of healthy sperm.

Of the three tiger cubs delivered by Caesarian section from the surrogate mother, only Mary Alice survived. One cub died shortly after birth from respiratory complications and the other died from viral pneumonia when it was several weeks old.

And so the research continues. In August, scientists aim to fertilize fresh tiger ova with sperm that has been frozen, and will also attempt for the first time a laparoscopic transfer of tiger embryos.

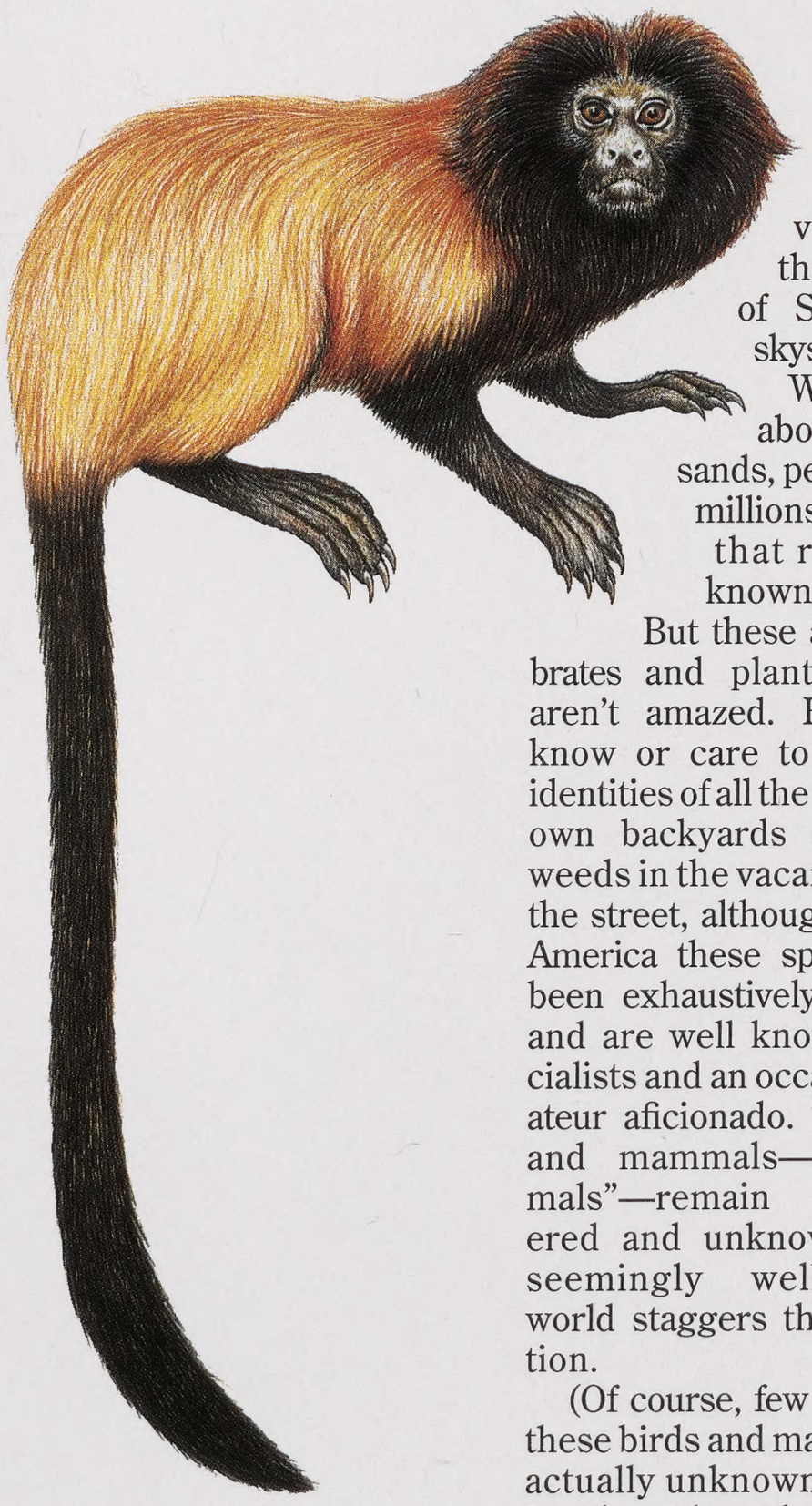
—Pat Janowski

The Last Elephant



BOB HUMPHREY

A professor of anthropology at George Washington University, Bob Humphrey has done archaeological field research in the Potomac Valley, American Southwest, northern Alaska, and Mesoamerica. His cartoons have appeared in numerous publications and he is currently working on a book of "Last Elephant" cartoons.



*The black-faced tamarin (*Leontopithecus caissara*). (Illustration by Stephen Nash, courtesy of Conservation International.)*

New Species

Just weeks ago, the discovery of what may be a new species of lion tamarin was announced in Brazil. Named the black-faced tamarin, this close relative of the golden lion tamarin was found living on a tiny island near Sao Paulo. Just think about it. In 1990, it is still possible to find a medium-sized mammal, a primate no less, that no one knew existed—and to find it virtually in the shadows of Sao Paulo's skyscrapers.

We hear a lot about the thousands, perhaps even millions, of species that remain unknown to science. But these are invertebrates and plants and we aren't amazed. Few of us know or care to know the identities of all the bugs in our own backyards or all the weeds in the vacant lot down the street, although in North America these species have been exhaustively cataloged and are well known to specialists and an occasional amateur aficionado. That birds and mammals—"real animals"—remain undiscovered and unknown in our seemingly well-explored world staggers the imagination.

(Of course, few or none of these birds and mammals are actually unknown to *anyone*: Local people are keenly aware of the species that live among and near them. But just as we say Columbus discovered America, so do we say that Western-trained biologists discover new species.)

In fact, biological exploration is a relatively recent phenomenon. Nearly two-thirds of Africa's ungulates, most of which are large and conspicuous, were not described to Western science until after 1800. African okapi, shy, forest-dwelling relatives of the giraffe that stand about six feet tall, were not discovered until 1901. Kouprey, wild cattle that weigh in at up to a ton, were not discovered in the forests of Indochina until 1937. In 1988 alone, a new species of muntjak deer was found in the mountains of Yunnan, China, and a new monkey—the sun-tailed guenon—was found in the rainforest of Gabon in equatorial Africa.

The Iriomote cat, a relative of the leopard cat, was found in 1967 on the tiny Japanese island that gave the cat its name, and more recently, in 1989, a survey of another Japanese island revealed a hitherto unknown subspecies of the leopard cat. The Andean mountain cat was known from only a few museum skins dating from the late 1800s until one was briefly sighted in 1980.

New bat species continue to be identified. The world's smallest bat and mammal, Kitti's hog-nosed bat, was discovered in Thailand in 1974; and even in Western Europe, three new species of bats were found in the last 25 years. Many others are known from one or two museum specimens and haven't been seen since the specimens were acquired.

Many of the thousands of tropical bird species described in the 19th and early 20th centuries, some on the basis of just a few specimens, similarly have not been seen in many years—in some cases because no one has looked. And, as with mammals, new species of birds continue to be discovered. In the last decade, surveys of South America, particularly in the Andes, have turned up one or two new bird species a year.

All of these birds and mammals, both those recently discovered and those that might be considered lost, are quite obviously rare, existing in low numbers in small areas. Most live on islands or in island-like patches of habitat. The sun-tailed guenon appears to be entirely confined to an area of less than 4,000 square kilometers bordered on three sides by large rivers. Superagui, the island where the new tamarins were found, is only 140 square kilometers while Iriomote is less than 300 square kilometers. Many, perhaps all, of these species are in danger of extinction simply because they are rare. Indeed, it is likely that some are already extinct and some others are gone that were never described.

A few years ago, conservation biologist Jared Diamond questioned the assumptions of endangered species list-makers, who assume a species is secure—and still in existence—unless there is good evidence that it is not. These assumptions probably seriously underestimate the number of species at risk of extinction or already extinct. Diamond proposes assuming a species is extinct or endangered unless we can show it is not—an assumption that would swell the lists and more accurately represent the magnitude of our biodiversity problem. For birds and mammals, the lists might grow from the current few hundred to perhaps thousands of endangered species. Somehow the list should also include a "fudge factor" to represent the species still to be found as they are almost certainly already endangered.

African conservationist Jonathan Kingdon describes a species as "the realization of a unique possibility of existence." Each is an irreplaceable treasure, a masterpiece of nature. We are richer for each one found, poorer for each lost.

—Susan Lumpkin

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